Report on the Strategic Options for the Modernization of the Department of Veterans Affairs Electronic Health Record

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Grant Thornton

Table of Contents

Strategic Options for the Modernization of VA's EHR

1.0 Executive Summary

The Department of Veterans Affairs (VA) engaged Grant Thornton to assess four strategic options for modernizing its Electronic Health Record (EHR)[1]. VA's EHR has not kept pace with industry and does not adequately support the current and future needs of Veterans and VA clinicians. This analysis assessed the market's ability to meet VA's needs through these four strategic options.

Figure 1. EHR Strategic Options

Option 1: COTS	Adopting a Commercial-of-the-shelf (COTS) product for the EHR where VA hosts the solution in a VA purchased, federally certified, secure cloud environment
Option 2: COTS +eHMP/JLV	Adopting a Commercial-of-the-shelf product for the EHR including the Electronic Health Management Platform (eHMP) and the Joint Legacy Viewer (JLV), where VA hosts the solution in a VA purchased, federally certified, secure cloud
Option 3: Commercialized Vista	Providing a gold standard VistA version to a vendor to modernize and provide back to VA as a Software as a Service (SaaS), where the vendor hosts the solution in a federally certified, secure cloud, and provides discounted licensing
Option 4: COTS SaaS	Adopting a COTS product for the EHR where the vendor hosts the solution in a federally certified, secure cloud, and VA licenses software use

The analysis found that the market can provide for VA's EHR needs with low variability in cost among the options leaving the primary differences in the value VA will place on the benefits and risks of owning and administering the software and the degree of influence and autonomy that VA can exercise. *Option 3: Commercialized VistA* is the least expensive option but carries the greatest risk. Potential modernization partners include immature start up business that carry risk in sustaining their business and risk in scaling to the VA enterprise. Other potential partners include mature businesses who do not anticipate adequate economic return for their investment due to low potential market capture. *Option 2: COTS + eHMP/JLV* is the most expensive option and is less aligned with OI&T's strategic priority to buy first. However, both *Option 3: Commercialized VistA* and *Option 2: COTS + eHMP/JLV* provide VA the highest degree of tailorability.

Comparatively, *Option 1: COTS* and *Option 4: COTS SaaS*, cost the same and primarily vary in the control and flexibility VA retains over the EHR. If VA hosts the EHR, it has greater flexibility to integrate new solutions as they emerge in the market, but would bear the responsibility for hosting, which requires IT investment and skills. Unlike *Option 4: COTS SaaS*, where the vendor would bear the responsibility for hosting the EHR, VA would have to negotiate the addition of new solutions during contract negotiations. Because the decision among the strategic options resides on trade-offs between a few key factors, the next section will address those factors and their trade-offs.

[1] According to the Healthcare Information and Management Systems Society (HIMSS), "Electronic Health Record (EHR) is a longitudinal electronic record of patient health information generated by one or more encounters in any care delivery setting. Included in this information are patient demographics, progress notes, problems, medications, vital signs, past medical history, immunizations, laboratory data and radiology reports. … The EHR has the ability to generate a complete record of a clinical patient encounter - as well as supporting other care-related activities directly or indirectly via interface - including evidence-based decision support, quality management, and outcomes reporting."

Key Decision Criteria and Trade-offs

We evaluated the strategic options against VA's clinical and IT priorities, strategic direction and future trends in healthcare and health IT to derive the decision criteria. Figure 2 highlights how each option addresses the key decision criteria.

Figure 2. Decision Criteria applied to each Option

Decision Factor	Option 1: COTS	Option 2: COTS + eHMP	Option 3: Commercialized VistA	Option 4: COTS SaaS
Time to Initial Operating Capability (IOC)	• Out-of-the-box functionalities fulfilling >80% of VA's needs • Estimate 18-24 months to IOC ~ Pilot Site post acquisition	• Out-of-the-box functionalities fulfilling >80% of VA's needs • Additional time to re-design and scale eHMP to COTS solution • Estimate 18-24 months to IOC ~ Pilot Site post acquisition	• Requires modernizing a single instance of VistA software prior to implementing, which will add at minimum an additional 12 months • Estimate 24-36 months to IOC ~ Pilot Site post acquisition	• Out-of-the-box functionalities fulfilling >80% of VA's needs • Estimate 18-24 months to IOC ~ Pilot Site post acquisition
Interoperability with other health systems	• All top tier COTS vendors meet multiple interoperability standards (e.g., FHIR) to create longitudinal record	• Same as Option 1: COTS. Also, JLV provides a static view of external records, but does not create the longitudinal record • eHMP to provide longitudinal record	• Interoperability capability would have to be built into the commercialized VistA solution	• All top tier COTS vendors meet multiple interoperability standards (e.g., FHIR) to create longitudinal record
Flexibility	• VA administered cloud increases VA flexibility to access 3rd party vendors (e.g., best in class population health)	• Same as Option 1 for COTS • eHMP for new capabilities over time, dependent on development time, which may exceed market timeliness	• Vendor administered cloud decreases VA flexibility to access 3rd party vendors (e.g., best in class population health) because vendors may have pre-existing agreements.	• Vendor administered cloud decreases VA flexibility to access 3rd party vendors (e.g., best in class population health) because vendors may have pre-existing agreements.
Modernity	• Industry leading software that regularly upgrades based on best practices and industry innovation • Fully integrated solution with modern team based communications	• Same as Option 1 for COTS • eHMP functionality would need to be de-conflicted of overlapping capability and then integrated with the COTS product.	• Vendor's commitment to continuous upgrade contingent on ability to sell the solution at other clients and make a profit • VA may have to invest or enter into risk sharing arrangements if the vendor is not able to sell the solution to a critical mass to break even	• Same as Option 1: COTS
Tailorability	• COTS out-of-the-box capabilities allow software configuration to meet end-user practice preference (e.g., physician note templates)	• Same as Option 1: COTS • eHMP adds capability to tailor because it is a VA developed and managed product	• Highest level of tailorability • May require additional cost to purchase leading business and clinical workflows from 3rd party entities	• Same as Option 1: COTS, except code level change (customization) may not be possible because software may be shared by other clients of the COTS vendor (e.g., DoD)

Decision Factor	Option 1: COTS	Option 2: COTS + eHMP	Option 3: Commercialized VistA	Option 4: COTS SaaS
	• Code level change (customization) incurs additional cost			
IT Strategic Alignment	• Aligns with all the strategic priorities except cloud is VA administered	• Does not align with the following strategic priorities: buy first, reduce IT footprint	• Aligns with all IT priorities	• Aligns with all IT priorities
Cost	• Total = $16.2B • Includes $184M for VA cloud hosting	• Total = $18.7B • Includes $525M for eHMP cost	• Total = $11.9B • Assumes $830M software costs absorbed by vendor	• $16.0B • VA does not incur hosting costs
Relative Risk	• Medium risk since vendors implement their solutions in this manner routinely	• Higher risk due to continued reliance on internally developed software	• High risk due to limited partner viability or appetite	• Medium risk since vendors have SaaS models in place

Figure 3 provides a detailed breakdown of 15-year costs associated with each option. Grant Thornton surveyed industry to determine the typical cost breakdown of EHR implementations and used the software costs provided by vendor estimates to extrapolate the total cost of vendor and prime integrator costs. Additional details regarding the basis for costs are provided in the Section 4.0 of this document as well as in Appendix D.

Figure 3. Rough Order of Magnitude 15-year Costs of Four Options

Cost Component	Option 1: COTS	Option 2: COTS + eHMP	Option 3: Commercialized VistA	Option 4: COTS SaaS
Vendor Costs				
Software Implementation Cost	$4,211,574,074	$4,736,574,074	$1,507,526,047	$3,327,143,519
Post-Go-Live Software Cost	$1,332,060,606	$1,332,060,606	$1,170,000,000	$2,664,121,212
Vendor Total	**$5,543,634,680**	**$6,068,634,680**	**$2,677,526,047**	**$5,991,264,731**
Services Cost				
Change Management Cost	$1,052,893,519	$1,527,858,025	$1,109,047,840	$1,109,047,840
Data Migration Cost	$505,382,301	$505,382,301	$505,382,301	$505,382,301
Prime Integrator	$2,161,941,358	$2,161,941,358	$1,707,933,673	$1,707,933,673
VA PMO Cost	$2,315,962,964	$2,565,954,091	$2,328,407,136	$2,328,407,136
Cloud Hosting	$184,673,700	$184,673,700	-	-
Services Subtotal	**$6,220,853,842**	**$6,945,809,474**	**$5,650,770,949**	**$5,650,770,949**
Contingency	$2,352,897,704	$2,602,888,831	$1,665,659,399	$2,328,407,136
Subtotal	**$14,117,386,226**	**$15,617,332,985**	**$9,993,956,395**	**$13,970,442,816**
Complexity Factor*	$2,117,607,934	$3,123,466,597	$1,998,791,279	$2,095,566,422
Grand Total	**$16,234,994,160**	**$18,740,799,583**	**$11,992,747,674**	**$16,066,009,238**

* Due to the early stage of planning for the EHR modernization, lack of business and technical requirements, and the complex nature of transitioning from 130 instances of VistA, we expect additional complexity and cost to be identified during the planning phase of this effort. We therefore added a 15% complexity factor to Options 1 and 4 and a 20% complexity factor to Options 2 and 3 to account for their respective complexities.

Summary

Multiple strategic paths exist for VA's EHR Modernization, each with their own risks, costs and benefits. Understanding the relative value of the different decision criteria will help VA to make its decision. When assessing this relative value, it is helpful to think about the state of VA at two points in time: 1) One (1) year after acquisition of a new EHR, and 2) Ten (10) years after acquisition. These two points in time reflect key junctures where VA will want to understand what success looks like, after which VA can determine which options are most critical to that success. Secretary Shulkin described success for VA at one year as a time similar to where DoD is now with a decision made, a pilot in one area, and steady, deliberate progress being made. For the ten year juncture, research materials and interviewees described a modern health system with readily exchangeable information and tools that enable advanced analytics, including precision medicine and population health, and intelligence into clinical workflows and decision making. Framing a VA leadership discussion around success at these two junctures and prioritizing the decision criteria, will enable VA leaders to select an option that creates a shared vision of success and is in alignments with the full organization's strategic direction.

2.0 Background

The Veterans Health Administration (VHA) is the largest integrated healthcare system in the United States, providing care at more than 1,200 sites of care, serving more than 8.9 million Veterans each year.[1,2] In many ways, VHA provides care to Veterans similarly to how their commercial counterparts provide care to the general population. However, VHA has a unique mission, patient demographic and disease burden (e.g., combat and exposure related conditions) that has an impact on how they manage the Veteran population and how they execute their quartet mission of caring for the Veterans, supporting medical research, providing medical education and serving as a back-up to DoD during national emergencies.

VHA's goal to provide whole healthcare to Veterans, no matter their geographic location or economic circumstance, drives the need for a network providing the full range of integrated physical and mental healthcare, where clinicians strive to understand health and wellbeing of their patients across all clinical domains and across the Veteran's entire life, to include during times of service and as Veterans, whether they receive care from VA, Department of Defense (DoD) or community care providers.

Because of the demographics of the Veteran population – living in locations from densely urban to sparsely populated – VA must also enable its clinicians to communicate with, treat and support their patients using the most advanced technologies available. To support this mission, VA is assessing available technologies to replace its current electronic health record (EHR) system with a more modern, adaptable technology that can leverage the innovations made in the commercial market to support the whole healthcare of Veterans across the country.

Currently, VHA's EHR runs on the Veterans Information Systems and Technology Architecture (VistA), a platform that was originally developed as a home-grown system more than 30 years ago to support clinical care delivery (with other management functions added over time) and still managed by VA today. At its inception, VistA was a revolutionary concept in healthcare management and served as an industry catalyst in the development of commercial EHR vendors such as Cerner and Epic. Over the years, VistA has proven to be a durable platform for automating both clinical and operational processes and workflows. In fact, VA currently uses VistA to handle supply chain, security, inventory management and a number of other operational activities, in addition to clinical operations such as order entry and pharmacy.

VistA has worked for VA for many decades and has leveraged new technologies such as Bar Code Medication Administration (BCMA) and management support capabilities such as supply chain, inventory management and human resources. Several factors, however, have led VA to question whether continuing with VistA is the best path forward. This is especially true now that more agile and technologically advanced EHR platforms are readily available in the commercial sector that can serve as the launching pad for delivering functionalities (e.g., clinicians reviewing and editing Veteran records and images remotely, Veterans scheduling appointments using mobile devices) that have already become common in the commercial market while adopting new innovations (e.g., provide virtual health including video communication and vitals assessment).

These factors include:

- *Technology*: The level of complexity in VistA has increased over the years due to several factors, including the development of VistA into multiple instances as each facility changed its code. In addition, limited enhancements delivered in recent years have led to several sub-modules of VistA lagging behind its commercial off-the-shelf (COTS) counterparts in functionality (e.g., lab, radiology, scheduling). While VA has been a leader in developing and deploying telehealth capabilities, it has fallen behind commercial products in integrating these capabilities within VistA. Additionally, the financial, administrative and other support modules in VistA have lost ground relative to COTS products and do not provide the expected level of service and capability in features such as dynamic/on-demand scheduling, population health and patient engagement. In many ways, industry innovation in EHR technology has leapfrogged VA. This sentiment was echoed by VHA field leadership where three out of five respondents surveyed agreed to the clinicians' desire to have advanced capabilities where the EHR could self-populate the Veteran's information from multiple sources and provide them with salient points and lead them through the visit with minimal keying of data into the system.

> *We have been leaders in integrated electronic health records, big-data analytic capabilities, and comprehensive care, including provision of support for team-based primary care, integration of behavioral health services, attention to social determinants of health, and caregiver involvement. – Dr. David Shulkin, 2016*[54]

- *Complexity*: While clinicians expressed appreciation for the ability to customize VistA to meet their local needs, more than three out of five VHA clinicians and leadership surveyed felt that VistA and its clinical packages were not as user friendly as they could be. They said that "there are too many clicks necessary to get where you need to go, and too many screens to navigate." Local customization and work arounds have increased the level of complexity and made the integration of new capabilities across the enterprise even more challenging. The downstream impact of high variability and complexity without a universal data model and integrated data management is that data is recorded in different ways across different and often incompatible systems leading to clinician frustration and potential adverse Veteran experiences, such as continuing to send appointment reminder notifications to a Veteran's widow even after the Veteran's death. Lack of standardization can also cause clinical practice variation and may impede organizational ability to pursue emerging models of care and to perform population health analytics.

- *Interoperability*: VistA is deployed throughout VA in a decentralized manner, with 130 instances hosted at VA data centers throughout the country. Coordination and communication among the individual instances of VistA can be a challenge. In addition, with more and more Veterans relying on both VA and community care providers, seven out of ten VISN directors and VHA leadership surveyed felt that information coming from outside providers need to be a part of the record to provide high quality and integrated care. Therefore, to deliver on VHA's mission, VA needs to adopt a platform that can promote and support seamless interoperability of Veteran's health record within the enterprise, with DoD and across organizations in the community. Interoperability and data sharing across disparate systems is an area of growing focus within the health care community and VA with its sheer size and scale can potentially be the catalyst to drive change.

- *Cost*: Recent studies suggest that VA Office of Information and Technology (OI&T) spends as much as 85 percent ($3.6B) of its annual budget on infrastructure operations and maintenance. That leaves only 15 percent to spend on enhancements and innovations for all VA systems. This level of continued cost to maintain and upgrade VA's IT infrastructure is unsustainable for VA if it plans to modernize its technology footprint and support its clinicians in delivering quality care to its Veterans.

For these reasons, VA leadership is evaluating strategic options that include commercial solutions for its EHR. In support of VA's decision making process, Grant Thornton conducted this strategic analysis to support Secretary of Veterans Affairs Dr. David Shulkin's decision, focusing on VA's future clinical and IT strategies and current and future market trends VA should consider when making a decision.

2.1 Objective

Secretary Shulkin announced in January 2017 that he would make a decision regarding the future of VA's EHR platform in July 2017.[3] VA directed Grant Thornton to conduct an independent assessment of four strategic options for modernizing its EHR, with a focus on technological aspects of the implementation. The four strategic options are as follows:

- *Option 1- Commercial off-the-shelf (COTS) EHR:* VA selects and implements a COTS EHR product and uses it for clinical and revenue cycle functionality. Although not all needs may be met by a single vendor, VA has the option to purchase additional COTS functionality and incorporate/integrate it with the primary COTS solution. The COTS EHR product will be hosted within a VA-purchased and operated, federally-certified, secure cloud environment (e.g., Amazon Web Services, Microsoft Azure).
- *Option 2 - COTS EHR combined with the Joint Legacy Viewer (JLV) and electronic Health Management Platform (eHMP):* This option is similar to *Option 1: COTS* plus VA retains the JLV and eHMP, both VistA packages, to develop and implement additional capabilities to fill gaps in COTS EHR capabilities. The COTS EHR product will be hosted within a VA-purchased, federally-certified, secure cloud environment.
- *Option 3 - VistA commercialization:* VA transfers VistA to a third-party vendor, and after modernization by the vendor, VA purchases licenses to use VistA as Software as a Service (SaaS). VA will receive considerations for pricing such as reduced licensing and implementation costs in exchange for VistA intellectual property rights. VA may also negotiate other terms such as directed development of new functionality to meet VA's specific requirements. In the SaaS arrangement, the vendor provides the software on a subscription basis and is responsible for hosting the software in a federally-certified, secure cloud environment.
- *Option 4 - COTS EHR provided as SaaS:* This option is similar to *Option 1: COTS*; however, in this option, the COTS EHR product is hosted and fully supported and managed by the vendor. In the SaaS arrangement, the vendor provides the software on a subscription basis and is responsible for hosting the software in a federally-certified, secure cloud environment.

This paper provides a high-level assessment of the four strategic options introduced above and the associated costs for implementing each option. The paper does not provide a recommendation on EHR vendors, but instead, shares insights captured from VA clinicians, leadership and staff regarding their needs or priorities and how they map to the capabilities offered by each strategic option. To ensure long-term success, the paper also provides key considerations around assessing and upgrading VA's technology infrastructure and hardware so that they may be able to support the strategy and solution preferred by VA.

2.2 Guiding Principles

Selecting an EHR is not just a technology decision; it is an organizational decision. Both the EHR selection process and ensuing implementation will be profoundly transformative. The guiding principles are intended to be enduring and will drive strategic evaluations regarding IT and change management.

Technology and change management decisions must be balanced relative to business and clinical, operational, and architecture and engineering principles. Doing so will maximize the business value of IT as it relates to EHR, mitigate programmatic and technical risks, smooth change integration, enhance systems and data quality, and ensure predictability and transparency in outcomes. These principles are factored into the assessment.

2.2.1 Business and Clinical Principles

- Patient safety and quality care are not compromised during EHR transition.
- A modernized EHR supports Veteran-centered, quality-driven, data-driven, evidence-based and team-based care.
- Clinical priorities drive EHR functional needs. IT trends and disruptive innovations can enable/inform EHR system functions. Requirements are driven by stakeholder principles (e.g., clinician, researcher, care team).
- EHR standardization is balanced with managed configurability.
- A modern EHR is flexible and can adapt to current and future healthcare and information technology trends.
- EHR information is integrated across care settings (e.g. outpatient, inpatient, operating room, emergency department, long-term care, mental health, and telehealth) and provides a longitudinal view of the Veteran's record.
- Decisions are optimized for VA and achieve economies of scale.
- Innovation and agility are non-negotiable.

2.2.2 Operational Principles

- Change management and standardization of clinical processes (including business process reengineering) and data are critical to the success of EHR modernization. EHR modernization must be minimally disruptive to hospital and clinic operations.
- VistA EHR legacy represents the baseline. Consequently, clinical excellence cannot regress as a result of IT changes during EHR modernization.
- VA leverages EHR lessons learned and leading practices from other large scale healthcare organizations (e.g., Kaiser Permanente, DoD and Mayo Clinic).

2.2.3 Architecture and Engineering Principles

- An EHR system should be architected from a system-of-systems perspective, optimizing systems quality (e.g., reliability, scalability, maintainability, usability, etc.).
- EHR systems should promote open architecture and standards so that clinical tools remain available to public and private sector providers.
- An EHR should incorporate standardized business processes and define standardized data and information models, taxonomy and terminologies.
- Data is an essential asset, so integrity and quality must always be sustained. There is zero tolerance for data loss during the transition to a modern EHR system.

- The EHR must be designed and implemented to provide seamless interoperability with DoD and community care providers, and encourage collaborative partnerships.

2.3 Analysis Framework and Approach

In evaluating the four strategic options, Grant Thornton leveraged our strategic evaluation framework for adoption of new enterprise technologies, which is comprised of Strategic Fit and Culture; Functionality and Technology; and Cost/Schedule and Viability (Figure 1 on next page).

- Strategic Fit and Culture contains the business drivers and needs for the technology. In this case, strategic fit and culture assesses the needs and desires of the end user clinicians, Veterans and other EHR users, to determine the right high-level expectations any solution must meet. These often include anything from specific technological options and features, to conformity to an organization's culture, mission and approach. We determined the appropriate strategic and cultural fit criteria through research and interviews with key stakeholders, as described below. Effectively, however, strategic fit and culture criteria focused on the clinical priorities of the organization.
- In Functionality and Technology, we assess the alignment of the solution with the organization's technology strategy and capabilities. Any decision regarding a significant technology investment must take the technological strategy into consideration. We determined the appropriate functionality and technology criteria through analysis of organizational strategy, interviews with stakeholders, Congressional testimony and other speaking engagements by VA leaders, and through review of published materials.
- Cost/Schedule and Viability is simply the assessment of each option's overall costs, any differentiation in schedule and the likelihood of successfully implementing each. We assessed these criteria by applying our experience and expertise supporting similar implementations across industry, and by researching similar implementations in government and commercial healthcare organizations.

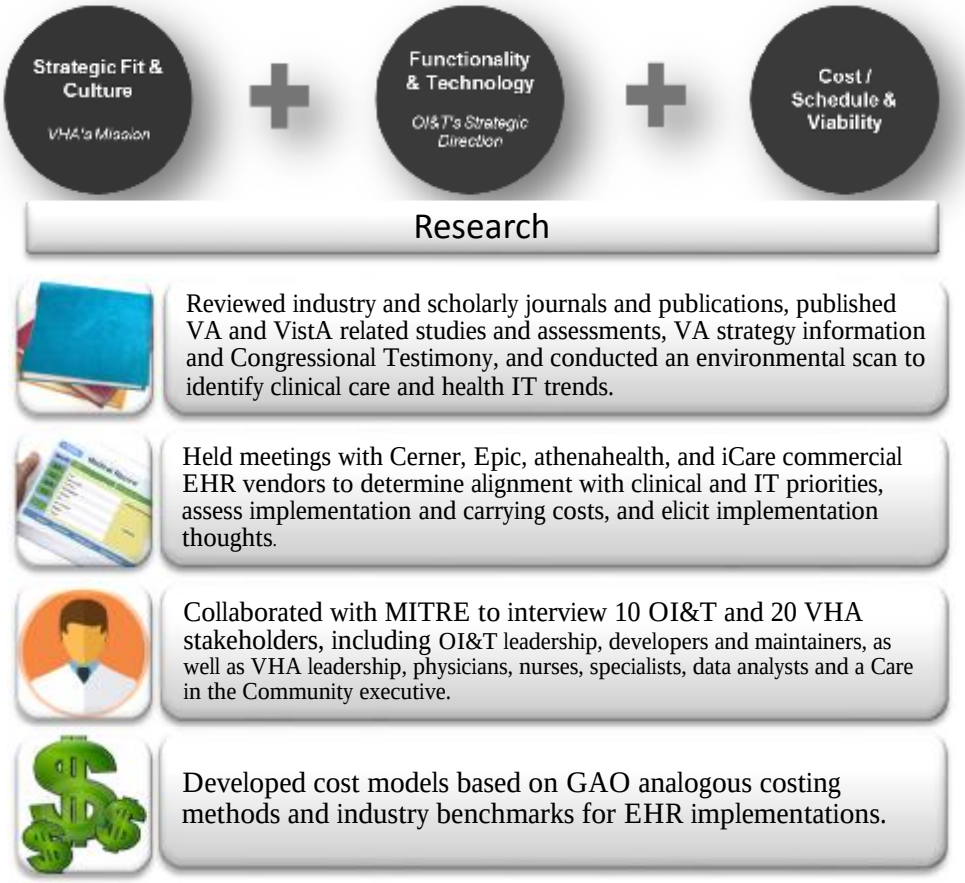
Grant Thornton interviewed key stakeholders across VHA and OI&T to determine the critical factors customers are seeking in a new EHR solution. Interviewees included:

- VHA and OI&T leadership
- Product development professionals with experience supporting VistA and the eHMP
- IT operations and maintenance staff, to understand how VistA is deployed and understand their recommendations for how VA can improve its sustainment footprint
- VHA clinicians and other EHR end users, including primary care, specialty care, allied health professionals, nurses, and revenue cycle staff

The results of the interviews are captured in Appendix B, but facts and findings derived from the interviews are outlined in the Strategic Fit and Culture, Functionality and Technology, and Cost/Schedule and Viability sections below.

Grant Thornton also conducted market research focused on identifying trends in healthcare delivery and health IT that would bear on the decision regarding EHR modernization. Market research included the study of industry publications and research, including Gartner and Forrester, medical journals, leading-edge technology development and the use and management of enterprise data. Market trends identified as impacting the EHR decision are discussed in Appendix C.

Figure 1. Research Framework



Finally, Grant Thornton met with leading EHR vendors to discuss their product offerings and assess fit with VA and OI&T's strategic priorities with respect to the EHR. We assessed products against these priorities, identifying those factors available in the commercial market and those factors that are not. We also discussed pricing methodologies and requested high-level cost estimates to align with our industry research on cost of adopting commercial EHR systems.

3.0 Findings

In order to modernize VA's EHR and enhance its ability to carry out the mission of supporting and providing healthcare for America's Veterans, VA has identified four potential options, each with its own series of benefits and risks, as well as unique cost profiles and trade-offs.

When assessing each of the options, the following should be considered:

- *Gaps in specific vendor capability:* In assessing alignment with VA's clinical priorities, we determined that although all priorities are met in the commercial market as a whole, a single vendor may not be able to meet VA's specifications completely, depending on the vendor selected. For example, a single vendor may achieve 90 percent of the solution to VA's specifications, but the other 10 percent is available through other vendors.

  - This increases the importance of the VDP should options 1 or 4 be selected. Through the VDP, VA could integrate best-in-class offerings to fill gaps of a single vendor. In essence, the best-of-breed COTS solution must support the multitude of VA care settings and stakeholders.
  - Alternatively, in preparing the solicitation, VA could list out all specifications and place the burden on the bidder to fill gaps, ensuring a complete solution. An integrator would then be responsible for combining all necessary capabilities into a comprehensive EHR solution.

- *Interoperability and care in the community and interoperability:* In assessing interoperability, there is great focus on the interoperability between DoD and VA. However, in interviews and in assessing the care continuum for military members as they serve and transition to Veteran status, the interoperability with DoD is critical at the transition stage, but no more important thereafter than interoperability with community care providers. Therefore, interoperability with DoD alone should not drive the decision regarding the option, or the eventual vendor solution.

- *Buy-first rather than buy-only:* In assessing the options and alignment with IT priorities, it is important to note that the "buy-first" strategy is not a "buy-only" strategy. VA has specific needs that others in the market do not, therefore there is the potential that commercial products may not meet all of VA's needs. This is especially true when considering other management information systems, but may apply to the EHR as well. During interviews, VA staff expressed concern that commercial vendors do not have some of the capability that exists now in VistA; however, the analysis showed that these assumptions are inaccurate and that many of the requested capabilities are in fact available in commercial EHR solutions. Additionally, in many cases, a solution that achieves a vast majority of VA's desires is more cost-effective than building a system from scratch.

3.1 Strategic and Cultural Fit

This section provides detailed descriptions around the clinical priorities that emerged as important to VA that align with their strategy and culture. They address five areas: unique features, workflow, team based care and mental health. Upon completing our interviews with VHA staff members and leaders, we asked a group of executive leaders from around the country to rank the identified clinical priorities. The two priorities that were most highly rated were having a single view of Veteran data, and support of team-based care.

> *[VHA's vision is to] continue to be the benchmark of excellence and value in healthcare and benefits by providing exemplary services that are both patient-centered and evidence based. This care will be delivered by engaged, collaborative teams in an integrated environment that supports learning, discovery, and continuous improvement. It will emphasize prevention and population health and contribute to the Nation's well-being through education, research, and service in national emergencies.*[53]

- *Features unique to VA:* VA has several aspects of their care delivery and patient population that are different than in the non-Veteran healthcare delivery market. These include factors such as:
  - Complex eligibility standards and requirements that exist for Veterans to receive VA healthcare, which impact revenue cycle operations (e.g. inability to bill third parties for service-connected care).
  - Disproportionate disease prevalence in the Veteran population for certain conditions such as amputations, traumatic brain injury, post-traumatic stress disorder (PTSD) and specific

environmental exposures (e.g. Agent Orange), which require the ability to establish and analyze patient cohorts not typically used in the commercial sector.
  - Broad and increasing emphasis on interaction with community care providers that underscores the need for more sophisticated interoperability and better methods of communication between VA clinicians and non-VA providers.
  - A disproportionately high rural population, with 5.2 million Veterans who constitute more than 30 percent of VA's caseload, which requires sophisticated remote capabilities.
  - A whole health focus that integrates management of psychological, social and physical health.

- *Workflow:* Workflow includes the sequencing of activities a clinician will use to treat a patient; it is adaptable to the specific conditions of the patient but standardized across the enterprise. Specific workflow considerations include:
  - *Longitudinal view of the patient record:* For the purpose of this analysis, VHA clinicians described the longitudinal view of the patient record as the ability to review medical information from community and DoD providers within the Veteran's record in one place, rather than needing to access multiple systems for information. Having a single source for all Veteran records is important so that clinicians can provide high quality care based on timely, accurate information and can also prevent medical errors and reduce waste resulting from duplicate laboratory tests or imaging.[4–6] Veterans' care is unique in that they transition from their military service to Veteran status, and their setting of care also changes from DoD to VA and community care providers. A longitudinal view for each patient in an EHR should include current and previous patient demographics, progress notes, problems and medications, as well as vital signs, past medical history, immunizations, laboratory data and radiology reports.
  - *Improved telehealth, mobile and web-based tools:* Due to the geographic dispersion of Veterans across the country, many of whom live in rural areas, VA often employs alternate methods of care delivery. VA Telehealth Services uses both synchronous (e.g. real-time videoconferencing between patients and a care team, remote medical device monitoring) and asynchronous (e.g. acquirement of and transmission of medical data for later review by providers, patient video education modules) communication to supplement face-to-face appointments and make receiving care more convenient for Veterans.[7,8] These initiatives have improved Veteran satisfaction by reducing travel and wait times.[8,9] In addition, providers endorse improved access, care coordination, and quality of care.[9]
  - *Scheduling:* Making it easier to schedule appointments, both face-to-face and via telehealth services will improve efficiency and experience for both clinicians and Veterans.

- *Team-based care/PACT*: There is increasing recognition of the value of team-based care to patients and providers, both in the primary care domain and for treatment of complex medical conditions.[10,11] The patient-centered medical home (PCMH) is one way in which team-based care is delivered, and VA has implemented this through the development of PACT. Implementation of a modern EHR can support PACT through the ability to manage relevant personal health information, allow communication among providers, patients, and care teams, analyze and report on individual and cohort outcomes and quality of care, support providers' clinical decision making, and help patients self-manage their health and medical conditions while collaborating with providers.

- *Analytics and research:* VA stakeholders all stressed the importance of analytics in delivering care. As defined through our interviews, VA clinicians are concerned with two primary types of analytics: real-time clinical decision support tools, powered by analytics, to support the clinician at the point of care; and retrospective analytics, which can support better management of the organization and its workforce, as well as improve care delivery through identification of trends that point to better

outcomes through different care approaches. The modern EHR should support both of these capabilities, by providing point-of-care analytics in a manner convenient to the provider, as well as the ability to conduct statistical and other analytics on the vast amount of data VA generates.

- *Mental health*: Mental health is one of Secretary Shulkin's top priorities; there is a long history of programs and interventions to support Veterans, who are at higher risk for mental health conditions in general, and specifically suffer from higher incidence of PTSD and suicide. VA has long had a well-integrated mental health program that considers the care of the Veteran holistically and is provided in concert with other care that the patient receives from VA. New technologies have the potential to improve risk stratification and tracking of Veterans to support their mental health, especially through vulnerable periods like the transition from active duty to Veteran life. VA stakeholders also described the need for specific options within the EHR to support documentation of mental health appointments, findings and diagnoses that are not available in VistA.

3.2 Summary of Alignment with Strategic and Cultural Fit

After interviews and demonstrations by multiple commercial EHR vendors, Grant Thornton assessed each option with respect to these priorities. There are COTS products that have features addressing all the priorities endorsed by VHA, to include the single view of data and support for team-based care, thus Options 1, 2, and 4 fully align since they all include a COTS product. For *Option 3: Commercialized VistA*, an appropriate vendor contract must ensure alignment with all priorities.

Figure 2. Option Alignment with Clinical Priorities

Clinical Priorities	Option 1: COTS	Option 2: COTS + eHMP	Option 3: Commercialized VistA	Option 4: COTS SaaS
Addresses features unique to VA	●	●	●	●
Workflow	●	●	●	●
Team-based care	●	●	●	●
Analytics and research	●	●	●	●
Mental health	●	●	●	●
Interoperability with DoD and community providers	●	●	●	●

● Complete ◔ Partial ◑ Limited ○ Not Aligned

3.3 Functionality and Technology

The second part of our evaluation framework is the functionality and technology associated with the different options. For several years, OI&T has focused on maintaining a significant number of legacy IT systems, including VistA. VA also developed customized software to meet the business needs of its customers, currently spending 85 percent of the IT budget on maintaining physical and application infrastructure. The high percentage of spend reflects both inefficiency in the system and

a level of need that outpaces VA's budget authority. Recently, OI&T began a transformation to decrease the demand for legacy systems and decrease inefficient IT management; and, is now focused on the following key objectives.

- *Single-view of the Veteran and data management:* Data management is critical for providing reliable and actionable data. Within industry, this entails the establishment and systems-based enforcement of holistic data governance models and data standards between and within systems to ensure that critical information is readily available, accurate, and actionable. Within VA, this means that a valid solution will ensure that critical health information is uniquely linked to the Veteran and centrally available at critical decision points. For VA to realize its goal of a single view of the Veteran's record, VA data must be stored within a standardized data model to facilitate the reliability and interoperability of the data between VA, DoD other Federal partners and community providers to provide a longitudinal view of the Veteran and to facilitate continuity of care.

> *The road ahead is clear, as the VA transforms itself to address future requirements. We need to strengthen our business processes so as to support clinical excellence and accelerate operational improvements to better serve veterans. By rethinking our systems, working with our current partners, and exploring new public–private partnerships, the VA is transitioning from a loose federation of regional systems to a highly integrated enterprise. – Dr. David Shulkin, 2016*[54]

- *Strategic sourcing:* Strategic sourcing is an industry and government standard practice of leveraging the combined buying power of large institutions toward a single vendor in order to gain more favorable procurement agreements. While VA has been successful in using its size and buying power to greatly reduce the cost of pharmaceuticals, for example, it has not historically leveraged this capability in the IT arena. VA's strategic sourcing effort is also focused on using VA's size in the market to incent vendors to develop capabilities and technologies that will benefit the healthcare delivery market as a whole.

- *Buy-first approach:* Application development is a resource-intensive process and requires tremendous effort to deliver a complete and viable solution. As such, it is only strategically advantageous to pursue this activity when it provides a tangible benefit to VA beyond what is readily available in the commercial space. For VA, this approach requires a transition away from in-house application development and towards sourcing and implementing commercially standardized, supported and maintained applications. Adopting a buy-first approach with respect to EHR applications will enable VA to leverage commercial experience and resources in caring for Veterans.

- *Reduced IT footprint:* OI&T currently spends 85 percent of its annual budget on maintaining its diverse IT footprint resulting in high opportunity costs for resources that could be applied elsewhere to advance VA's central mission. To effectively execute the strategy, VA is considering using commercial operational resources and Software/Platform as a Service (SaaS/PaaS) options, such as cloud computing, distributed and on-demand infrastructure, and support options. VA must consider scalability, support and hosting options and network and bandwidth requirements when evaluating EHR options and ensure that the options are able to operate effectively with and within distributed computing, platform and network environments.

- *Cloud-based:* An emerging trend within the U.S. healthcare industry is the application of cloud-based (i.e. distributed computing) environments to address the myriad infrastructure issues and shifting requirements faced by the demands of the modern healthcare environment. The application of cloud-based computing allows the supporting infrastructure of EHR systems to scale up or down to

fit the size of the organizational need. For large distributed institutions such as VA, this provides a number of tangible benefits, cost savings and strategic options that are not available with traditional, on-premises environments, such as scalability, drastically reduced hardware costs, maintenance efficiencies and the ability to leverage the large, robust commercial networks that span the country. Currently, VA operates its EHR solution within a series of VA-owned and maintained data centers. This architecture requires a large number of resources to be dedicated solely to infrastructure support. However, by transitioning VA's EHR infrastructure to the cloud, VA could potentially realize substantial resource savings and redirect those resources toward other, more Veteran-focused initiatives. In evaluating its future EHR options, VA will want to consider solutions can fully operate within the modern, cloud-based computing environments.

Figure 3. Alignment to Strategic Evaluation Criteria

Evaluation Criteria	Option 1: COTS	Option 2: COTS + eHMP	Option 3: Commercialized VistA	Option 4: COTS SaaS
Single-view of the Veteran and data management				
Strategic sourcing				
Buy-first approach				
Reduced IT footprint				
Cloud-based				

As illustrated in Figure 3, Options 1, 3, and 4 fully align with VA's IT strategic direction. *Option 2: COTS + eHMP* partially aligns because it relies on internal VA development to support and advance the eHMP, which does not align with the strategic sourcing and buy-first.

In addition to VA's IT strategy, we identified technical evaluation criteria to assess VA's current capabilities to support the options under consideration. The technical evaluation criteria are:

- *Network resource requirements*: Network resources are required by any solution that requires any machine, service, process or facility to connect to another. In broad terms, network resources affect the speed and responsiveness of activities within both the EHR interface and between the EHR environment and ancillary systems. Every solution will require a certain level of network resources in order to operate, however, the specific limiting resources can be drastically different between the options and this evaluation will focus on the bandwidth, connectivity, latency mitigation and topological layout of each considered solution.

- *Adaptability "future proofing":* Adaptability is the capacity of a solution to be flexible enough in terms of allowed clinical processes and workflows and underlying and integrated technologies to meet VA's immediate needs while providing a stable and robust platform to support the new care models and technologies. While all enterprise class EHRs will be configurable to address the immediate needs of VA, certain architectures will be more accessible and adaptable in terms of data and processes, which

will allow VA greater ability and a lower barrier to mold a given solution to changes in the clinical landscape.

- *Scalability:* Simply put, scalability is the ability of a solution to efficiently scale to an organization the size of VA. Scalability takes into account not only the approach and architecture needed to scale a solution, but the level of complexity in both required systems and processes necessary to achieve this. Additionally, this takes into account the complexity of migrating workflow and processes between sites as well as the ease of expanding or contracting solution instances.

- *Redundancy:* In order for VA to continue to operate and provide critical services to Veterans, any EHR system must be adept at effectively providing needed information to doctors, nurses and other clinical staff at all times while still providing a "single view" of the Veteran. Additionally, it must provide methodology to ensure that records are not lost or corrupted, that no or minimal single points of failure exist within the network, and address concurrency issues arising from interruptions in end-to-end network coverage across the VA system.

Figure 4 illustrates each solution's degree of alignment with the above technical evaluation criteria. As templated, all solutions fulfill the intentions of these criteria to a curtain extent, however *Option 2: COTS + eHMP* has minor abrogation relative to the other solutions.

Figure 4. Alignment to Technical Evaluation Criteria

Evaluation Criteria	Option 1: COTS	Option 2: COTS + eHMP	Option 3: Commercialized VistA	Option 4: COTS SaaS
Network resource requirements				
Adaptability				
Scalability				
Redundancy				

Options 1 and 4 differ in adaptability due to differences in implementation model, namely SasS (*Option 4: COTS SaaS*) to non-SaaS, where VA's ability to modify their solution is attenuated be the constraints of the SaaS implementation. Under a SaaS option, VA would not have direct access to the database backend and thus would be slightly limited in the capability to directly interface with the data and thus to conduct operations on said data without going through an intermediary approved by the SaaS provider.

Option 2: COTS + eHMP allows for a high degree of adaptability due to its utilization of the eHMP project which allows VA to directly drive the future capability of eHMP and thus the solution itself. However, this capability is realized through the implementation of additional software on-top on the COTS EHR resulting in increased network demands and increasing the effort necessary to scale and establish redundancy analogous to an infrastructure supporting a COTS system without the addition of the eHMP's needs.

3.4 Benefits

The adoption of an enterprise-wide, standardized commercial EHR product, supported by a vendor with an established track record and well-integrated modules may improve the perception of VA and underscore the organization's commitment to providing high quality care to Veterans in the 21st century.

Figure 5. Benefits of Options

Benefits Category	Evaluation Criteria	Option 1: COTS	Option 2: COTS+ eHMP/JLV	Option 3: VistA Comm.	Option 4: COTS SaaS
Defined product roadmap	• Clear vision for software evolution • Ability to keep pace with market demands, trends and innovations	HIGH	MEDIUM	LOW	HIGH
Access to and ownership of data	• VA has direct administrative and/or system authority	HIGH	HIGH	LOW HIGH	LOW HIGH
Ability to customize EHR product	• VA has the ability to direct product development	MEDIUM	HIGH	HIGH	LOW

- *Defined product roadmap:* Established COTS vendors are expected to have a long term vision for their product growth strategy that can help them stay on top. Options 1, 2 and 4 offer VA such an opportunity to partner with leading COTS vendors who may be able to quickly modernize VA's care delivery process and help the agency realize its mission of Veteran-centric care. However, that *Option 2: COTS + eHMP* is rated slightly lower than Options 1 and 4 because within *Option 2: COTS + eHMP*, the eHMP package is still in its early stages of deployment as it has not yet been scaled to the enterprise level or designed to integrate with non-VistA EHR's. Similarly, *Option 3: Commercialized VistA* is also rated lower on the defined product roadmap benefit scale compared to the other options because in this scenario, the vendor is expected to design and build a custom EHR tailored for VA.

- *Access to and ownership of data: Option 1: COTS* and *Option 2: COTS + eHMP* include implementation on a VA-managed, federally-certified, secure cloud environment. While VA will not own the actual servers or data centers, they will directly manage the cloud environment and database engines supporting the EHR, and would have direct access to the live data stored within the EHR. Therefore, direct access and control to the live data and the ability to use it with any third-party solutions desired without outside vendor involvement are the primary reasons for rating Options 1 and 2 higher than Options 3 and 4. However, VA can mitigate the concern for access to the data for Options 3 and 4 by ensuring appropriate language is included in the contract for the EHR that guarantees VA's right to access the data for any reason, and to allow VA to connect any third party software VA chooses directly to the SaaS environment and solution, regardless of other agreements the COTS SaaS vendor has made. This agreement would likely have cost implications that could not be estimated, as this type of arrangement is atypical.

- *Ability to customize EHR product*: While VA may not be able to customize a COTS product at the facility level because of its size and scale, VA has the ability to influence the vendor's product development at different degrees. However, Options 2 and 3 provide greater flexibility for VA to customize the solution. For instance, *Option 2: COTS + eHMP* leaves open the possibility for VA to develop capabilities on its own through the eHMP, while Option 3: Commercialized VistA provides VA the option to direct or otherwise have a significant voice in the future development of the solution. Comparatively, *Option 4: COTS SaaS* rates the lowest in terms of customizability because of its SaaS arrangement.

Each option provides benefits to one extent or another. In applying the benefits to a decision regarding the modernization of the EHR, VA leadership can determine which benefits are more important to VA going forward, and then assess the benefits against the other factors assessed in this paper.

3.5 Risks

There are always risks associated with any large enterprise-wide system implementation. The figure below highlights key risks VA leadership must be aware off when selecting the best strategic option for EHR implementation. The risks were identified and analyzed based on VHA and OI&T stakeholder interviews, COTS vendor interviews and demonstrations, industry research and Grant Thornton experience conducting EHR implementations.

Figure 6. Risks of Options

Risk Category	Evaluation Criteria	Option 1: COTS	Option 2: COTS+ eHMP	Option 3: VistA Comm.	Option 4: COTS SaaS
Transitioning to a cloud environment	• Experience with cloud • Resource skillset	HIGH	HIGH	HIGH	MEDIUM
Backup and disaster recovery management (DRM)	• Infrastructure reliability • Redundancy protocols in place	HIGH	HIGH	LOW	LOW
Integration of third-party COTS applications	• COTS capabilities can address VHA's needs (e.g., population health, decision support, mental health, user-friendly, secure messaging)	LOW	LOW	MEDIUM	MEDIUM
Loss of control over future EHR capabilities development*	• VA's level of autonomy and control over its future EHR solution	HIGH MEDIUM	MEDIUM	LOW	HIGH MEDIUM
Demand on network infrastructure	• Relative bandwidth requirement at the VAMC and satellite facilities	MEDIUM	HIGH	MEDIUM	MEDIUM
Required additional development	• Maturity of software and its capabilities	LOW	HIGH	HIGH	LOW

Disruption to workflow during implementation	• Clinical workflows and business processes will be redesigned	HIGH	HIGH	HIGH	HIGH
Availability of Vendors	• The known availability of vendors in the market that can support the option.	LOW	LOW	HIGH	LOW

*Traditionally, this risk is high as commercial vendors control the product roadmap. VA however could reduce this risk by contractually requiring some control over the direction the vendor takes with the product.

- *Transitioning to cloud environment:* VA has 35 years of experience developing and managing their own data centers and other on-premises installations of VistA and supporting software. However, transitioning to a cloud environment requires different skill sets and competencies. The skill gap and lack of experience with cloud management poses risk, as existing experienced system administrators and managers would have to undergo retraining or new system administrators would need to be hired. Hiring new administrators would require training in VA processes and operations. This risk is common to both Options 1 and 2, as both of these options have the COTS EHR hosted within a VA-purchased, federally-certified, secure cloud environment where VA's OI&T resources are responsible for managing and administering the data and the hardware setup within the cloud environment. Option 3: Commercialized VistA is also high risk because without a defined partner, VA does not yet know whether the eventual partner will be conversant in cloud deployment. Finally, *Option 4: COTS SaaS* is less risky to VA because the vendor is already operating a SaaS environment for other clients. There is some risk due to scaling to VA's needs, but this is not as high as Options 1-3.

- *Backup and disaster recovery management (DRM):* As VA transitions to a cloud environment, backup systems and disaster recovery will need to be considered in new ways and existing back-up plans would need to be reevaluated. Migration to a commercial cloud provider – as in Options 3 and 4 – alleviates the hardware component of disaster recovery. However, VA would still bear responsibility for ensuring that failover and redundancy protocols work seamlessly to minimize disruption to clinical workflow and have zero impact to patient safety. The management and planning of these activities is a significant undertaking given the size and complexity of VA.

- *Integration of non-COTS EHR applications:* Unlike Options 3 and 4, VA would own the COTS solution in Options 1 and 2. Therefore, by leveraging the VA Digital Platform strategy in Options 1 and 2, VA can potentially connect with any non-COTS EHR application in the market to achieve its desired goals. However this advantage would be significantly reduced in Options 3 and 4 where VA has limited direct control of the software due to potential contractual restrictions and SaaS implementation.

- *Loss of control over future EHR capabilities development:* While the adoption of a COTS EHR solution allows VA to keep pace with industry leaders in health care information technology, VA may still encounter limitations with a COTS solution because a COTS vendor may be either unwilling or incapable of providing VA-requested, non-standard enhancements and functionality post go-live. Options 1 and 4 are considered high risk for this reason, but the risk could be lowered should VA ensure contract language allows them to direct the development of future capabilities. We therefore assessed the options as either high or low, dependent on VA's ability to negotiate such development control. *Option 2: COTS + eHMP* is less risky because VA would be able to adapt eHMP in the future to accommodate new technologies it can develop. Finally, *Option 3: Commercialized VistA* is low risk

because VA would negotiate some control over future development and incorporation of new technologies.

- *Demand on network infrastructure*: *Option 2: COTS + eHMP* may have greater bandwidth requirements at VAMC and satellite facilities than Options 1, 3, and 4 as the network will have to accommodate traffic from both the EHR and the eHMP applications; this could be burdensome in areas where bandwidth is limited.

- *Required additional development*: While the ability to direct development is a benefit, an associated risk is that of taking on additional development. Options 2 and 3 by design require further development and customization. For instance, the eHMP software was designed specifically for VistA and therefore the software in its current version (2.0) will require code level redesign to seamlessly integrate with a COTS product. Likewise, the commercialized VistA in *Option 3: Commercialized VistA* also requires code level upgrades so that it can address both the unique requirements of VA along with the modernized features found in standard COTS products. Thus, Options 2 and 3 share a much higher risk compared to Options 1 and 4 that do not require code level updates.

- *Disruption to workflow during implementation*: All four options carry significant risk in disruption to existing workflow. This is inherent in a change to any new solution. VA will manage the risk through significant investment in change management, training, and hands-on support during and immediately after implementation.

- *Availability of Vendors*: Options 1, 2 and 4 are all low risk due to the availability of several vendors in the market to support the option (either through the COTS solutions or through continued development of eHMP). *Option 3: Commercialized VistA* however, is high risk. In assessing several the type of partner VA needs to make *Option 3: Commercialized VistA* successful, there may be few, if any, vendors in the market willing to support this option. Because of the criticality of finding a viable partner for this option – success is completely contingent on it – *Option 3: Commercialized VistA* should be viewed as an overall high risk.

As with benefits, the options hold differentiated risk as compared with one another. The critical factors in deciding on a modernization approach is determining the level of risk appetite the organization has, and which types of risk are more acceptable. These risks can then be balanced against alignment with strategy, benefits and costs.

3.6 Summary of Non-Cost Assessment

As noted in the Executive Summary, the combination of alignment with clinical and IT priorities, benefits and risks, provide the best opportunity to assess the options against one another. VA leadership, upon determining the relative importance of these factors, can use the analysis in Figure 7 below, to support the decision:

Figure 7. Decision Criteria applied to each Option

Decision Factor	Option 1: COTS	Option 2: COTS + eHMP	Option 3: Commercialized VistA	Option 4: COTS SaaS
Time to Initial Operating Capability (IOC)	• Out-of-the-box functionalities fulfilling >80% of VA's needs • Estimate 18-24 months to IOC ~	• Out-of-the-box functionalities fulfilling >80% of VA's needs • Additional time to re-design and scale eHMP to COTS solution	• Requires modernizing a single instance of VistA software prior to implementing, which will add at minimum an additional 12 months	• Out-of-the-box functionalities fulfilling >80% of VA's needs • Estimate 18-24 months to IOC ~ Pilot Site post acquisition

Decision Factor	Option 1: COTS	Option 2: COTS + eHMP	Option 3: Commercialized VistA	Option 4: COTS SaaS
	Pilot Site post acquisition	• Estimate 18-24 months to IOC ~ Pilot Site post acquisition	• Estimate 24-36 months to IOC ~ Pilot Site post acquisition	
Interoperability with other health systems	• All top tier COTS vendors meet multiple interoperability standards (e.g., FHIR) to create longitudinal record	• Same as Option 1: COTS. Also, JLV provides a static view of external records, but does not create the longitudinal record • eHMP to provide longitudinal record	• Interoperability capability would have to be built into the commercialized VistA solution	• All top tier COTS vendors meet multiple interoperability standards (e.g., FHIR) to create longitudinal record
Flexibility	• VA administered cloud increases VA flexibility to access 3rd party vendors (e.g., best in class population health)	• Same as Option 1 for COTS • eHMP for new capabilities over time, dependent on development time, which may exceed market timeliness	• Vendor administered cloud decreases VA flexibility to access 3rd party vendors (e.g., best in class population health) because vendors may have pre-existing agreements.	• Vendor administered cloud decreases VA flexibility to access 3rd party vendors (e.g., best in class population health) because vendors may have pre-existing agreements.
Modernity	• Industry leading software that regularly upgrades based on best practices and industry innovation • Fully integrated solution with modern team based communications	• Same as Option 1 for COTS • eHMP functionality would need to be de-conflicted of overlapping capability and then integrated with the COTS product.	• Vendor's commitment to continuous upgrade contingent on ability to sell the solution at other clients and make a profit • VA may have to invest or enter into risk sharing arrangements if the vendor is not able to sell the solution to a critical mass to break even	• Same as Option 1: COTS
Tailorability	• COTS out-of-the-box capabilities allow software configuration to meet end-user practice preference (e.g., physician note templates) • Code level change (customization) incurs additional cost	• Same as Option 1: COTS • eHMP adds capability to tailor because it is a VA developed and managed product	• Highest level of tailorability • May require additional cost to purchase leading business and clinical workflows from 3rd party entities	• Same as Option 1: COTS, except code level change (customization) may not be possible because software may be shared by other clients of the COTS vendor (e.g., DoD)
IT Strategic Alignment	• Aligns with all the strategic priorities except cloud is VA administered	• Does not align with the following strategic priorities: buy first, reduce IT footprint	• Aligns with all IT priorities	• Aligns with all IT priorities
Cost	• Total = $16.2B • Includes $184M for VA cloud hosting	• Total = $18.7B • Includes $525M for eHMP cost	• Total = $11.9B • Assumes $830M software costs absorbed by vendor	• $16.0B • VA does not incur hosting costs
Relative Risk	• Medium risk since vendors implement their solutions in this manner routinely	• Higher risk due to continued reliance on internally developed software	• High risk due to limited partner viability or appetite	• Medium risk since vendors have SaaS models in place

4.0 Cost Assessment

Grant Thornton applied a three step approach to develop high-level cost estimates for each option under consideration:

- Applied the analogous costing methodology as defined by the Government Accountability Office (GAO) Cost Estimating and Assessment Guide[12]
- Met with EHR vendors, applied assumptions for software implementation in VA and requested non-attributable, rough order of magnitude (ROM) estimates from each
- Applied industry research and benchmarks for large-scale EHR and management information system implementations to identify and price various cost centers typical of these implementations

We provide a 15-year cost estimate for this analysis. The first ten years will be implementation years, as discussed in the timeline section below. The last five years provide an estimate for what VA may expect for annual software licensing and maintenance fees.

4.1 Analogous Cost Methodology

Grant Thornton used the analogous methodology for the following reasons:

- There are few data points available to consider in assessing cost for an EHR implementation in an organization the size of VA. Two analogous implementations include the DoD acquisition of Cerner and the Kaiser Permanente implementation of Epic. These were determined to be analogous due to the similar care delivery model, supporting a dedicated patient population through all care delivery. In addition, the total patient population for the three are similar.
- Since VA is in the early stages of planning the EHR modernization, specific business and technical requirements are not available to provide the basis of an engineering cost build-up.
- The timeframe available for analysis to support the cost estimate is relatively short for such a large and complex organization.
- At this stage in the decision, a ROM cost estimate is sufficient for the four options as the final solution costs will be highly dependent on the vendor chosen and could change during the vendor selection process as the vendor addresses VA's specific needs.

In assessing the DoD and Kaiser implementations, Grant Thornton determined that the total number of enrolled patients provided a reasonable benchmark in performing an analogous estimate. This assessment yielded the approximately $10.6B 10-year estimate used in the VA Digital Platform (VDP) paper provided to VA in December 2016.[13]

4.2 Vendor Discussions

To further refine the estimate for this paper, Grant Thornton engaged commercial EHR vendors to provide ROM estimates for the cost of software implementation and ongoing maintenance for VA. Grant Thornton provided the vendors a list of general assumptions and conditions for the EHR implementation scenario stipulating length of implementation, modules included and type of system solution offering. Upon review of the vendor-provided ROMs, it became apparent that these estimates generally agreed with the estimate delivered in the VDP report.

4.3 Industry Research and Benchmarking

The analogous methodology and vendor quotes produces top-line price estimates (e.g., total cost of implementation). In order to break the top-line cost into appropriate cost centers, we applied a further cost allocation breakdown developed through a survey of industry leaders who recently went through an EHR implementation. The cost breakdown we developed is in Figure 8.

Figure 8. Cost Allocation of Software Based on Industry Survey

Cost Component	Cost Allocation
Software	28%
Vendor Team & Support	41%
IT Infrastructure HW & SW (Hosting)	6%
Systems Integration	3%
Application Support	11%
End user devices	2%
User training at Go-Live	8%
Other Project Cost	1%
Total	100%

Next, due to the size and complexity of VA, we determined that a prime integrator would be required to support preparation for and implementation of the EHR. We identified an appropriate benchmark presented at the Health Information Management Systems Society (HIMSS) and applied it to our model. As shown in Figure 9, the effort of a prime integrator relates to the software cost with a ratio of 1.83:1.

Figure 9. Prime Integrator Cost (HIMSS)

HIMSS Component	Percent Cost
Software	30%
Labor	55%
Quotient	1.83

The final industry benchmark consists of a cost scalar derived from data provided by EHR in Practice[55]. Grant Thornton studied available data for both traditional and SaaS EHR implementations and based upon that data, derived a scalar which we applied to the COTS cost to determine the cost for SaaS implementation and post-go-live costs. The data showed that implementation costs for SaaS are approximately .79 those of a traditional implementation. However, ongoing licensing fees for the SaaS software and services is approximately two times the cost of the software in a traditional implementation.

4.4 Option-Specific Costs

Option 1: COTS – Option 1: COTS utilized the above methodology to determine the overall cost and breakdown to cost centers. We first rationalized multiple vendor quotes by breaking the quotes down against various cost types and then developed an average cost among all vendors. Next, we applied the benchmark cost allocations to determine appropriate costs for each cost center, and then added the prime integrator cost. Finally, we applied our implementation timeline and allocated the implementation phase costs across the ten year implementation phase, followed by five years of annual software costs.

Option 2: COTS + eHMP – This option carried the costs from *Option 1: COTS* since they both include implementation of a COTS EHR solution in a VA operated cloud environment. In order to cost the eHMP component of Option 2: COTS + eHMP, Grant Thornton utilized an internal VA estimate for the cost to deliver Version 2.0 of the eHMP to all users. This estimate was provided in a briefing to the Presidential Transition Team earlier this fiscal year. The estimate provided a one-time first-year cost of $96.6M to scale the product for use by all interested users and $30.6M for each year thereafter for 14 years for a total 15-year cost of $525M.[16] Note that this cost assumes no additional development activity.

Option 3: Commercialized VistA – Option 3: Commercialized VistA began with a similar costing methodology to *Option 1: COTS* above. We assessed the vendor quotes to determine an appropriate price for the implementation and post-implementation phases of the project and allocated the costs according to our benchmarks listed above. We then assessed the impact of the commercialization agreement. *Option 3: Commercialized VistA* entails an agreement between VA and a commercial partner. The partner would be responsible for upgrading the technology to meet all VA-identified clinical priorities, and to bring the technology up to industry standard. Because of the significant investment necessary to accomplish this goal, we assumed a trade-off arrangement between VA and the vendor. The vendor would make the initial investment to modernize the system. Since the vendor would then be able to market the product commercially, they have an interest in the modernization effort. VA also would benefit greatly, because they transition to a familiar product and ease the concerns of many employees who are invested in the VistA application. We therefore determined that the vendor would apply 50 percent of the cost to modernize the product to their VA agreement, while self-funding the other portion. We therefore added the VA portion of this modernization cost to the implementation phase of the cost model to account for the added cost of modernization.

Grant Thornton studied the VistA 4 Roadmap to determine the total cost to modernize VistA and meet VA's clinical priorities. Our full assessment is provided in Appendix D. As per above, 50 percent of that total was applied to the cost estimate for VA.

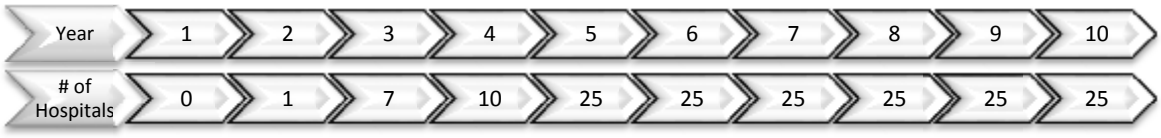
Option 4: COTS SaaS – To determine the cost of *Option 4: COTS SaaS*, we applied the industry benchmarked scalar model noted in the previous section to *Option 1: COTS* above. Note that per the scalar, while the implementation phase for *Option 4: COTS SaaS* is less costly, ongoing software costs are much higher. Therefore, although the 15 year model we present shows a lower cost for COTS SaaS, this option will become more expensive over its lifetime.

4.5 Estimated Implementation Timeline

We applied a 10-year implementation time frame as the basis for the cost estimate. We selected ten years due to the size and complexity of VA, allowing adequate planning and preparation time, as well as time for appropriate alpha and beta testing prior to full roll out. Our assumed timeline includes appropriate planning for the following:

- 12-18 months for preparation, planning and Project Management Office (PMO) stand-up for the implementation
- Beta test at one facility for the next 12-18 months to deploy the future Health IT/EHR in VA:
  - Capture clinical and business requirements and standardize workflows across the facility
  - Translate clinical data and design requirements to technical specifications required for build
  - Map standard reporting capabilities to clinical and operational requirements and develop custom reports as appropriate
  - Develop a robust testing methodology to including testing data flow across vendor and VA applications and outside in the community
  - Conduct integrated clinical use case testing, including regression and community connections
  - Conduct training of clinical and operational end users
  - Determine appropriate support for activation and deployment activities
- Alpha test for 12-24 months that includes expansion to other facilities in the beta site Veteran Integrated Service Network (VISN), and additional facilities in other VISNs to control for VISN variability
  - Confirm lessons learned based from the beta site on clinical adoption and interoperability with community providers utilizing Agile methodologies
  - Conduct user review and acceptance analysis of standardized clinical and business processes developed and implemented at the beta test site
  - Determine key drivers for the time duration would be deployment of standardized clinical workflow, training and testing
- Begin national rollout of the implementation phase.

Figure 10. Estimated Adoption Timeline



In order to show the annual maintenance cost for the modern EHR system, we then added five years to our estimate, so the total estimate provided is for 15 years, the first 10 of which is implementation.

4.6 VA Costs

VA will also incur internal costs to support the migration to a new, modern EHR. These include data migration costs, change management, and funding a PMO to act on VA's behalf (the PMO can either be staffed with internal VA resources, or through a contract).

To determine the cost of data migration, we analyzed a previous effort where VA was able to complete comprehensive data migration for 66 sites.[14] We assumed a similar level of effort per

facility would be required to migrate the full 130 instances of VistA. We aligned the timeline for data migration with the implementation timeline from above to determine the total number of sites VA must migrate each year and the total cost of migration.

To cost the change management portion, we leveraged our technical knowledge against a body of industry experience, as well as change management costs illustrated in the eHMP 2.0 rollout program. Change management costs are approximately 25 percent of a total projects aggregate cost, therefore a factor of 25 percent was applied to the overall project cost to calculate the change management cost.

PMO costs were determined by leveraging Grant Thornton's industry experience as well as analysis of pertinent Office of Management and Budget (OMB) Form 300s and select research into other large scale ERP, EHR and information technology implementation projects to determine an appropriate benchmark. Our analysis indicates PMO costs are generally between 15-20 percent of the overall project costs. We assumed the high-end due to the inherent complexity of the scale of VA and a factor of 20 percent was applied to calculate to the PMO cost.

4.7 Complexity Factor

Finally, due to the early stage of decision-making at VA, many factors that impact overall cost are not well understood. These factors include:

- Specific business and clinical requirements, which may identify additional software or integration needs, which may increase overall cost.
- A readiness assessment, which we recommend below, may identify additional internal costs such as infrastructure improvements or increased change management costs.
- Additional development needs in eHMP or VistA modernization.

We therefore added a 20 percent complexity factor for *Option 2: COTS + eHMP* and *Option 3: Commercialized VistA* and a 15% complexity factor for *Option 1: COTS* and *Option 4: COTS SaaS* to account for unknown costs that are likely to arise over the planning period.

Figure 11 provides the detailed breakdown of costs, per our analysis.[15] Appendix D provides full detail of the steps associated with developing each cost center, and the calculations performed.

Figure 11. 15-year Costs Associated with Four Options

Cost Center	Option #1: COTS	Option #2: COTS + JLV / eHMP	Option #3: Commercialized VistA	Option #4: COTS SaaS
Vendor Costs				
Software	$1,179,240,741	$1,179,240,741	$194,372,093	$931,600,185
Vendor Team & Support	$1,726,745,370	$1,726,745,370	$284,616,279	$1,364,128,843
IT Infrastructure HW & SW	$252,694,444	$252,694,444	$41,651,163	$199,628,611
Systems Integration	$126,347,222	$126,347,222	$20,825,581	$99,814,306
Application Support	$463,273,148	$463,273,148	$76,360,465	$365,985,787
End user devices	$84,231,481	$84,231,481	$13,883,721	$66,542,870
User training at Go-Live	$336,925,926	$336,925,926	$55,534,884	$266,171,481

Other Project Cost	$42,115,741	$42,115,741	$6,941,860	$33,271,435
eHMP (*Option 2: COTS + eHMP* only)	$0	$525,000,000	$0	$0
VistA Modernization (*Option 3: Commercialized VistA* only)	$0	$0	$813,340,000	$0
Software Implementation Cost	**$4,211,574,074**	**$4,736,574,074**	**$1,507,526,047**	**$3,327,143,519**
Post-Go-Live Software Cost	$1,332,060,606	$1,332,060,606	$1,170,000,000	$2,664,121,212
Vendor Total	**$5,543,634,680**	**$6,068,634,680**	**$2,677,526,047**	**$5,991,264,731**
Services Cost				
Change Management Cost	$1,052,893,519	$1,527,858,025	$1,109,047,840	$1,109,047,840
Data Migration Cost	$505,382,301	$505,382,301	$505,382,301	$505,382,301
Prime Integrator	$2,161,941,358	$2,161,941,358	$1,707,933,673	$1,707,933,673
VA PMO Cost	$2,315,962,964	$2,565,954,091	$2,328,407,136	$2,328,407,136
Cloud Hosting	$184,673,700	$184,673,700	$0	$0
Services Subtotal	**$6,220,853,842**	**$6,945,809,474**	**$5,650,770,949**	**$5,650,770,949**
Contingency	$2,352,897,704	$2,602,888,831	$1,665,659,399	$2,328,407,136
Sub-Total	**$14,117,386,226**	**$15,617,332,985**	**$9,993,956,395**	**$13,970,442,816**
Complexity Factor	$2,117,607,934	$3,123,466,597	$1,998,791,279	$2,095,566,422
Grand Total	**$16,234,994,160**	**$18,740,799,583**	**$11,992,747,674**	**$16,066,009,238**

5.0 Summary of Findings

Grant Thornton utilized our technology adoption approach to assess various options for VA's modernized EHR. The assessment identified the clinical and IT priorities, benefits, risks and costs of each of four options for EHR modernization presented by VA. Our assessment found significant overlap in capability with respect to clinical priorities, and for the most part, alignment with VA's IT priorities. Options differentiate to a greater extent when assessed against the real and potential benefits and risks. These provide a framework against which VA leaders may weigh the options against one another, and informed the decision-criteria discussed in the Executive Summary. While Grant Thornton was not asked to provide a specific recommended option, our analysis provides objective information upon which a decision may be based.

Figure 12 provides a summary of each option's alignment with VA's clinical and technology priorities, as well as the relative benefits and risks associated.

Figure 12. Alignment with Clinical Priorities & IT Strategic Direction

Evaluation Factors	Option 1: COTS	Option 2: COTS + eHMP	Option 3: Commercialized VistA	Option 4: COTS SaaS
Clinical priorities				
IT strategic direction				

Benefits	HIGH	HIGH	HIGH*	HIGH*
Risk	MEDIUM	HIGH	HIGH	MEDIUM

*Rating assumes VA inserts appropriate language into the contract to guarantee access to and control of data as well as ability to connect third-party software at will.

In addition, Figure 13 provides the high-level cost breakdown of each option.

Figure 13. Costs of Four Options

Cost Component	Option 1: COTS	Option 2: COTS + eHMP	Option 3: Commercialized VistA	Option 4: COTS SaaS
		Vendor Costs		
Software Implementation Cost	$4,211,574,074	$4,736,574,074	$1,507,526,047	$3,327,143,519
Maintenance & Support Cost	$1,332,060,606	$1,332,060,606	$1,170,000,000	$2,664,121,212
Vendor Total	**$5,543,634,680**	**$6,068,634,680**	**$2,677,526,047**	**$5,991,264,731**
		Services Cost		
Change Management Cost	$1,052,893,519	$1,527,858,025	$1,109,047,840	$1,109,047,840
Data Migration Cost	$505,382,301	$505,382,301	$505,382,301	$505,382,301
Prime Integrator	$2,161,941,358	$2,161,941,358	$1,707,933,673	$1,707,933,673
VA PMO Cost	$2,315,962,964	$2,565,954,091	$2,328,407,136	$2,328,407,136
Cloud Hosting	$184,673,700	$184,673,700	-	-
Services Subtotal	**$6,220,853,842**	**$6,945,809,474**	**$5,650,770,949**	**$5,650,770,949**
Contingency	$2,352,897,704	$2,602,888,831	$1,665,659,399	$2,328,407,136
Subtotal	**$14,117386,226**	**$15,617,332,985**	**$9,993,956,395**	**$13,970,442,816**
Complexity Factor	$2,117,607,934	$3,123,466,597	$1,998,791,279	$2,095,566,422
Grand Total	**$16,234,994,160**	**$18,740,799,583**	**$11,992,747,674**	**$16,066,009,238**

6.0 Recommendations

EHR modernization is a journey. While Grant Thornton makes no recommendation on which specific option VA should pursue, no matter the choice, the following is recommended in order to inform downstream decisions such as vendor selection (should a COTS solution be involved in the modern EHR), continued development of eHMP and other factors:

- *Technical readiness assessment:* During interviews, a number of VA personnel expressed confidence that VA had the necessary network infrastructure, bandwidth and other technical capabilities to move to the cloud or adopt enterprise-wide SaaS solutions. However, there were others including VA leadership, both nationally and in the field, who expressed reservations regarding the organization having the network capacity and bandwidth to support the EHR in the cloud. We recommend that VA conduct a study to validate these statements. Readiness assessment must also include facilities, data centers and security components.

- *Technical evaluation of eHMP:* During the interviews, some of the VA personnel shared their optimism that eHMP could help bridge the gap that currently exists around transparency and interoperability both across the different instances of VistA and also between VHA, DoD and the community providers. However, independent assessments of the technology and Grant Thornton's analysis of eHMP program documentation raise concerns as to the long-term viability of the product. A complete, independent assessment of eHMP from a technological standpoint is recommended to determine if it is scalable in its current form, and if not, the necessary additional cost to restructure the product so that it is scalable. In addition, it is also recommended that the assessment include eHMP's ability to integrate with COTS EHR solutions the way it promises to integrate with VistA.

- *Acquisition approach:* VA has specific and critical needs that impact any solution VA chooses. It is critical that VA's needs are properly documented in the clinical and technical requirements of any procurement. This needs to be supported by robust business and technical architectures (capability maps, process models), systems quality factors, service level agreements and enterprise design. In addition, contractual requirements must also address any needs VA has, such as ownership of and access to data. These contractual requirements should be assessed and included as requirements in the solicitation. Cost models are validated and Independent Government Cost Estimates (IGCE) are established. This must include garnering best practices and lessons learned from the DoD Genesis acquisition. It may also include proof of concepts, controlled pilots and phased rollouts.

- *Systems engineering and program management plan:* This should include strategy for requirements management, interface analysis, usability and human factors, architecture analysis and documentation, end-to-end testing, continuous risk management, development of performance metrics and an integrated master plan / schedule (IMP / IMS).

- *System (application) and hardware inventory:* OI&T should conduct a detailed assessment and inventory or each clinical location to ensure all software is catalogued to understand interface requirements. Additionally a detailed desktop, printer and ancillary hardware inventory needs to be conducted as all of these devices will need to be evaluated against any of the strategic options for future usability.

The studies and actions we recommend above will have an impact on the total cost to implement a solution. The readiness assessment may uncover additional necessary investment to improve the performance and bandwidth of the network infrastructure. The systems engineering and program management plan may also increase cost as additional requirements are identified the PMO or vendor must address. The results of these studies may also impact our findings from a benefits and risks standpoint, as significant change in network or organizational improvements to support the transition may introduce risks not assessed. However, these actions are critical to support the successful implementation of any solution.

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8.0 Appendix A: Macro Assumptions

In assessing the options, Grant Thornton made the following assumptions:

- Grant Thornton used the Health Information Management Systems Society (HIMSS) definition of an EHR, which states: "The Electronic Health Record (EHR) is a longitudinal electronic record of patient health information generated by one or more encounters in any care delivery setting. Included in this information are patient demographics, progress notes, problems, medications, vital signs, past medical history, immunizations, laboratory data and radiology reports. The EHR automates and streamlines the clinician's workflow. The EHR has the ability to generate a complete record of a clinical patient encounter - as well as supporting other care-related activities directly or indirectly via interface - including evidence-based decision support, quality management, and outcomes reporting."
- VA will implement the EHR as a component of the overall VA Digital Platform (VDP), as described in the strategy document published in 2016 "VA Digital Platform Strategy for Next Generation of Care at the VHA." The VDP establishes a platform on which the EHR operates with other management information systems, such as human resources, financial management and customer relationship management, as well as external EHRs used in the healthcare community, to include DoD. In addition, through the VDP, VA will be able to adopt other tools available in the market to augment core EHR capabilities.
- This assessment focused on the EHR components of VistA only (core clinical, clinical ancillary and revenue cycle). This paper does not address the modernization of other components of VistA such as police and security, financial management, supply chain or others. Appendix E contains a list of current VistA modules that constitute the EHR.
- In assessing implementation costs, the continued carrying costs for maintaining the VistA EHR were deemed to be equal no matter the option selected, therefore they were not considered during this analysis.
- VA currently houses backup copies of electronic health records locally at VA Medical Centers (VAMCs) in the event of network disruptions, in addition to hardware for the provision of the new EHR product. There will be minimal, if any, net new hardware costs incurred as part of the transition to a modern EHR.
- This assessment is based upon strategic needs of the organization, from both a clinical and technological perspective. Detailed business and clinical requirements are not yet defined. The cost assessment therefore uses an analogous methodology and provides a Rough Order of Magnitude (ROM) cost estimate. Additionally, based upon our analysis, the DoD and Kaiser Permanente EHR adoptions are analogous projects.
- Industry benchmarks related to the adoption of new EHRs are relevant to this assessment. Benchmarks include the relative percentage of costs attributed to software, hardware, change management and other factors, as well as the proportional cost of SaaS models versus traditional deployment.
- Three of the four options include the adoption of a COTS EHR solution. Although all clinical and IT priorities can be satisfied by COTS software, a single COTS vendor may not address all equally. Therefore, VA may choose to adopt a vendor for a majority of the EHR components and then add, through the VDP, best-in-class capabilities available through other vendors in order to fully meet its clinical and IT priorities.

9.0 Appendix B: Stakeholder Interview Findings

9.1 Clinical Stakeholder Findings

In order to understand the experience of clinicians using CPRS and VistA for both clinical and research work, several qualitative interviews were conducted with VHA clinicians (both physicians and nurses), including some who had expertise and leadership roles in health informatics and health information technology implementation. The VHA interviews were led by the MITRE collaboration with Grant Thornton. While the majority of clinicians expressed that they are able to collaborate well with other clinicians in order to provide excellent care to Veterans, numerous themes were compiled after these discussions regarding ways in which an EHR solution improve Veteran and clinician experience.

Based on multiple EHR vendor interviews conducted by Grant Thornton, it was felt that all four strategic options could support the needs and requirements of VHA clinicians and leadership. This section highlights essential themes that clinicians expressed with regard to selection and implementation of a modern EHR.

9.1.1 Leadership

Key Messages: Clinicians articulated a feeling that there is a lack of central governance and that the problems are greater than just EHR choice. Many felt that:

- The *change management* aspect of an EHR transition is significant and the VA needs to be committed to understanding workflows in order to improve the experience for Veterans and clinicians
- Some providers feel significant *trust between clinicians and IT has been lost over time* with respect to partnership in VistA and CPRS development. Part of this is related to the fact that EHR improvements are hampered by budget and approval processes, and additionally, disconnect exists between VA facilities and IT with respect to business planning.
- Regardless of past issues, a number of the clinicians expressed a need for *shared partnership with IT* to deliver quality Veteran-centric care
- Clinicians also feel that the *contracting process is too long* and bureaucratic and needs attention because by the time tools are eventually developed, they are obsolete.

9.1.2 Clinical Workflow

Key Messages: Providers desire modern EHR capabilities that are intuitive, efficient and allow the clinician to spend more time delivering direct care to the patient. The following are key themes shared during the interviews:

- There is *lack of single-sign on*, which makes it frustrating to go back and forth between different applications
- There is no ability for physicians to easily see their schedules and those of trainees they are supervising. This makes it *difficult to plan their day* because for example, they cannot see if a patient has canceled and then adjust.
- Multiple clinicians mentioned that they need an *integrated way for patient information* to be presented on an EHR screen that *interfaces with clinical decision support tools* and makes *documentation streamlined* and accurate
- Despite the recognition that alerts and reminders are important parts of patient safety, there are often *too many screens and clicks that clinicians must encounter*. One nurse noted that the computer admission

protocol takes up to two hours for an intensive care unit patient, and 45 minutes for a floor patient, significant time sinks for a nurse who has multiple patients and time-sensitive responsibilities

In addition to the above, there were more focused comments shared such as:

- Because of the decentralized nature of IT, facilities have taken to implement local solutions (both designed internally by local VA IT personnel and COTS products). One provider provided an example that while the COTS solution for their emergency department (ED) worked very well and allowed them to easily see recent Veteran ED visits and reasons, this system did not interface with CPRS. As such, if a patient was admitted to the hospital, an admitting physician could not easily see the ED record (information is saved in cumbersome PDFs).
- There Mixed feedback was shared regarding CPRS usability, with some providers expressing that they felt CPRS was very easy to use and intuitive (multiple providers noted that it worked very well for pharmacy) while others felt that COTS solutions were much more user-friendly and capable.

9.1.3 Team-Based Care/PACT

Key Messages: As discussed previously, VA has a strong commitment to providing effective team-based care for Veterans through the PACT initiative. Each PACT "teamlet" is comprised of a Veteran, a primary care provider (physician, physician assistant, or nurse practitioner), a registered nurse who functions as a care manager for the team, a licensed practical nurse or medical assistant, and a clerical assistant.[19–21]VA research has already shown that improved relationships with Veterans and speed of care received were noted positives of PACT.[19,20]Despite all of this, CPRS does not support PACT well. VA clinicians have created work-arounds to address these deficiencies, but one group of VA providers detailed several EHR features that would be beneficial in order to support team-based care (Figure B-1).

- Providers are not able to directly communicate through the EHR outside of patient records. A workaround that many use today is adding additional signers to patient notes, which creates an alert to another provider to sign that note, but does not allow for a direct specific message to that provider which is in the EHR but not in a patient note.
- There is no good way to manage panels of patients or cohorts based on clinical condition because of limitations in VistA's architecture.

Figure B-1. Clinical Team Needs for Team-Based Panel Management[22]

Clinical Needs	Relevant Technical Capability
Allow user to group patients by a specific clinical condition.	The system should have multidimensional report capability, allowing the user to specify time period, patient group, and selected clinical data at a patient level.
Provide summary Data on key clinical variables (e.g. lab tests, prescriptions) that are used as markers of quality of care for a group of patients.	Reports need to be able to summarize numerator and denominator information for the patient group of interest.
Need resources to facilitate patient outreach (e.g., personalized patient letters or handouts)	The database system should be able to link pertinent information at a patient level, and provide an ''on-demand'' synopsis per individual patient.
Ability to easily track care across time.	The database system should be able to access clinical data in a longitudinal fashion at the patient level.

Clinical Needs	Relevant Technical Capability
Facilitate collaboration among interdisciplinary providers.	The system must have a user interface that supports the needs of interdisciplinary clinical team members.
Provide timely data.	Data extraction from the electronic health record should be timely (preferably on a daily basis).
Need to be able to enter clinic-specific orders and requests.	Interface must have dual-way information flow between panel management tool and electronic medical record.

9.1.4 Analytics and Research

Key Messages: The desire for improved analytics and easier methods of accessing data for both clinical improvements and research were recurring themes expressed by clinicians and informaticists.

- Though many providers emphasized that the volume of data available for Veterans is impressive, *extracting this data usefully can be difficult and slow*.
- Clinicians described *difficulty with obtaining access to databases* and data warehouses and even once they do, they are *not user friendly*. Databases that users create often do not work outside a specific facility.
- Physicians note that they are expected to monitor their productivity but cannot view real-time metrics. Relatedly, users explained that it takes significant amounts of time to run reports that are needed quickly, which greatly hinders prospective research.

9.1.5 Mental Health

Key Messages: Mental health is an area of distinct importance to VA; there is a long history of programs and interventions to support Veterans, who at higher risk for mental health conditions in general, and others specifically such as post-traumatic stress disorder (PTSD) and suicide. Talking with providers allowed better understanding of some of the technology related challenges experienced by practitioners in this division.

- Veterans receive care from many providers and *coordination of care is difficult* to manage across multiple sites. This is especially critical at times of transition such as when Veterans are leaving active duty and are particularly vulnerable. Clinicians felt that there need to be *better methods for stratifying risk levels of patients* and tracking their care within an EHR.
- Providers would also like the *ability to easily code more detailed information* (e.g. the particular type of therapy provided or assessment completed.
- Documentation is highly narrative, and providers suggested that more *standardized ways of documenting health information* would be helpful.
- From the Veteran perspective, providers recommended *incorporating Veteran input and goals*, interventions and a care plan and allowing these to be integrated with the EHR. Currently, there are numerous self-assessment tools for Veterans but they do not connect with the EHR.

9.1.6 Interoperability

Key Messages: Many providers expressed numerous difficulties with sharing patient information outside the VA.

- Providers note that the majority of the time, if a patient is seen in the community, when their records are obtained they are largely in paper format and scanned into the EHR. They are linked as images/PDFs and *not integrated with the Veteran's clinical information* in CPRS, so they cannot be linked with clinical decision support tools or reminders.

- Providers note that if Walgreens and CVS can add immunization data into CPRS, it would be beneficial if other community providers could as well.
- Clinicians want *tools that connect with each other* better, such as kiosks or tablets into which Veterans can enter information and communicate with the EHR.

9.2 Validation of Findings with VHA Executive Leaders

Grant Thornton attended a VHA leadership dinner that included discussions surrounding the EHR Strategic Assessment. Along with seeking insights and feedback, a survey was administered to VHA leadership to compile stakeholder feedback and clinical priorities that were both discovered and considered throughout the stakeholder interviews and assessment period.

In the first part of the survey, participants were asked to identify which stakeholder feedback criteria resonated with them. Stakeholder feedback was narrowed down to the following categories; culture, communications, mental health, analytics and measurement, usability/tailorability, community care interviews, and package level discussion. The captured results are in Figure B-2 below.

Figure B-2. VHA Leadership Comments

	Description	Resonates (Number of times box was checked)	Percentage of results
Culture	There is a cultural legacy of partnership between clinicians and developers. Clinicians appreciate the ability to customize locally, working with developers to implement modifications to their instances of VistA. Several clinicians expressed satisfaction with this capability, and fear losing it with an enterprise COTS system.	18	55%
	Many clinicians will accept a change and are ready for a decision to be made. They are, however, reticent about the organization's ability to make a decision and successfully implement it.	20	61%
	Some concern of an exodus from VA for retirement eligible clinicians as they do not want to go through a difficult transition at this stage in their career.	8	24%
Communications	*Team-Based Care:* Communication between services is difficult now, so they have work arounds where they enter notes into the record and ask for a co-signature so another provider sees it and can respond. Need secure communications tools so the care team can interact without using the patient's record to do so.	16	48%
	With community providers: Care coordination and communication goes beyond just the care team. Communication with the patient, community providers, and others is important. Need a system that is easier to use for all parties. In the interview with Karen Hudgins, she noted that they are now up with encrypted email with community providers.	21	64%
	With the Veteran: Current capabilities with MyHealtheVet are clunky and hard to use. The Epic solution was brought up as a very good tool, used throughout the industry. VA should look to that type of solution to communicate with Veterans. Focus on mobile, getting ready for the younger generations.	14	42%

	Information Sharing: We overprotect the data and have too many security requirements that get in the way. Providers feel that it hinders their ability to perform their work. Other organizations are able to share data much more freely, why can't VA?	18	55%
Mental Health	Providers want better tools to support care coordination within and across medical centers – High risk patients often receive care at multiple locations	22	67%
	Ability to interact with Veterans outside the care setting and receive information. This includes the use of mobile technologies to support self-help and transfer of information to the provider.	19	58%
	Existing system is limited in the ability to provide care planning at the level VA needs. Providers however do not believe commercial products have the answer – most systems do not address mental health as completely as VA.	9	27%
Analytics and Measurement	Informaticists generally agreed that they appreciated the ability to extract and analyze data for clinical and research purposes with VistA and would want this to continue.	17	52%
	Clinicians expressed difficulty conducting analysis at the patient or cohort level with FileMan. They need to be able to dynamically analyze data at the patient, cohort, population, and eventual genomic level.	19	58%
	From a measures standpoint, it is important to be able to measure performance. However, simply looking at care metrics isn't sufficient to truly measure performance. Canned reports are not able to provide the information needed. Clinicians want to make sure they can perform analysis beyond what is available from a canned report.	17	52%
	While enterprise analytics is seen as a positive with VistA, at the provider level, they don't have the analytics capability they need (described by one clinician with VistA development experience that this is a challenge with MUMPS). Describe downloading data from FileMan, which takes a long time, then having to export to excel and work with it a lot to get what they need from the data.	14	42%
	Looking for dashboards to support patient care, analytics and decision support	3	9%
Usability and Tailorability	Clinicians liked the ability to develop tailored solutions in VistA and were concerned that commercial products will not allow the level of customization they are used to.	10	30%
	Current system is not as user friendly as it could be. There are too many clicks necessary to get where you need to go, and too many screens to navigate. Solution should better align with how physicians work to smooth the process.	21	64%
	Information coming from outside providers need to be a part of the record rather than having to go to different places. Provided example where Walgreens and CVS can now populate the record. Why not other providers?	23	70%
	General discussion of data availability is that current system has data in too many places, requiring the provider to jump between screens/systems to view information.	12	36%
	Reminders – Not aligned to specialty or need. All reminders hit the PCP, which puts them into a mindless clicking mentality. Reminders should go to the clinician that needs it, not just to the PCP.	18	55%

Innovations	Hospitals/VISNs are bringing in their own capabilities to bridge the gaps in technology (e.g., Cerner Lab). Lack of enterprise focus on new capabilities.	11	33%
	Feeling that OI&T is unable to support innovations, so the field has to do it. Example was given related to VistA multiple instances – Region 1 has built new capabilities in VistA (screens, workflows, etc.) and other regions can't take it in because OI&T can't always migrate these capabilities across the country.	20	61%
	Need to have a multi-disciplinary approach to IT innovation to understand how professionals work/work together.	17	52%
	One common theme on the future is having the medical record self-populate the information a physician needs to know coming into the visit, have the record "tell" the doctor the important/salient points and lead them through the encounter using decision support tools.	19	58%
Community Care interviews	There are currently five different legislative authorities for community care. This will make any claims management system hard to implement without customization. They are planning to merge the authorities into one authority, but not there yet. That would help with business rules around when to/not to pay.	14	42%
	Care coordination is also important with non-VA providers. Stakeholders talked about secure communications/encrypted email. They recently deployed that capability, but would like to do more to improve collaboration and coordination between providers.	17	52%
	Aligning what VA pays to community providers with third-party claims is important. Must be able to identify first and third-party claims received that can be charged to Veterans' insurance companies.	14	42%
Package-Level Discussion	Pharmacy – 80% of prescriptions filled by Consolidated Mail Outpatient Pharmacy (CMOP). The solution needs to account for this. It has to be an enterprise system that allows for CMOP and local staff to see everything. Feeling is that commercial products can support this, but there should still be an eye towards VA-specific needs.	17	52%
	Lab professionals articulated significant deficiencies with the lab package. The lab package has not been updated in a long time. VistA has difficulty importing lab data and updates cannot easily be made because they will break in other instances of VistA. They feel they need a relational database to handle their lab data. There is no lab information system and they are using middleware patches and products to try to manage this. They view VistA as archaic and a security risk with respect to lab. Other deficiencies in the current system include: microbiology, barcode reading, and order management.	21	64%

In the second part of the survey, participants were asked to rank the following clinical priorities on a scale of 1 to 5. Clinical priorities were grouped as care approaches unique to VA, workflow, team based care/PACT, analytics/research, mental health, and interoperability. Figure B-3 looks at the number of times a clinical priority was considered for ranking.

Figure B-3. VHA Leadership Survey

Category	Number of Times Ranked	Percentage of Rankings
Care Approaches Unique to VA		
Configuration required to address Federal requirements while serving a unique population base e.g., pharmacy, tele-health, mental health	1	20%
Workflow		
Single location for Veteran information – whether VA or community generated records.	16	52%
Improved tele-health, mobile and web-based tools/technologies for managing Veteran care	8	26%
Scheduling ease for Veterans and providers	11	34%
Team-based care / PACT		
Improved care coordination	17	45%
Improved communication tools	7	30%
Management of Veteran cohorts – supporting Veteran groups with similar health concerns	2	40%
Analytics / Research		
Clinical decision and cognitive analytics support - care for an individual Veteran	12	35%
Population health - leveraging large data sets to improve care for groups	11	24%
Performance improvement - tracking outcomes between VA facilities/regions	4	24%
Ability to easily access data for clinical and research purposes	6	24%
Mental health		
Seamless integration of mental health into EHR	12	28%
Interoperability		
Seamless bi-directional exchange of data with DoD, community providers, etc.	21	40%

9.3 OI&T Stakeholder Findings

In order to understand the experience of OI&T staff, both leadership and technical, qualitative interviews were conducted throughout the strategic assessment. These stakeholder interviews were led by Grant Thornton in collaboration with MITRE Corporation. The purpose of these interviews were to better understand how the four potential strategic options align with the following OI&T's

stated priorities: single-view of Veteran and data management, strategic sourcing, buy-first approach, cloud-based, reduced IT footprint, interoperable with VistA, COTS, DoD, community care providers, etc.

9.3.1 Clinician Input into EHR Design

Key Messages: Providers had concerns about the ability of a commercial product to take into consideration VHA clinicians' wants and needs in the implementation process. Stakeholders explained that during the original development of VistA and CPRS, clinicians and end users priorities and practices were strongly taken into consideration. It is *very important to VA clinicians to have say* in their clinical practices, workflows, tools, and processes that support them.

9.3.2 Absence of Data Standardization

Key Messages: The current VistA environment is lacking data standardization across VHA sites.

- Stakeholders suggested having every VAMC running the same code base *without pulling away facilities' abilities* to do their own specific processes.
- At the data level, *standardization is important* for sharing data between VAMCs and elsewhere (DoD/community). A key concern surrounding data standardization and the VA, is that the primary problem with instituting standards is that control is currently siloed into non-interconnected regional data stores

9.3.3 Questioning Contractor Value

Key Messages: Third-party contractors are not providing true value to the VA. Stakeholders said that *contracts are limiting in nature*, which they feel prevents meaningful work from occurring. This restriction along with the contractor's unfamiliarity with VistA, and requirements not being effectively communicated, leads to inefficiency and poor results.

9.3.4 Development of Business Requirements

Key Messages: Developers expressed throughout the interviews that business processes and requirements created are not useful to developers but rather primarily designed for congressional needs and OI&T and VHA leaderships' priorities. Stakeholders felt OI&T and VHA leadership should develop of business requirements that allow for successful projects and mitigate change in project scope and direction.

9.3.5 Difficult System Navigation

Key Messages: Navigating between modules and search functions within the current system architecture is *extremely difficult* due to multiple log-ins and fire walls. Stakeholders expressed interest in incorporating single sign-on, and application interconnectivity into the new solution that VA decides to move forward with.

9.3.6 Network Capacity to Support New Solution

Key Messages: Several stakeholders expressed concern about limitations in VA's network inhibit future development

- lack of network segmentation by asset class was mentioned by one stakeholder

- A concern expressed during one interview was that VA's network does not have the available bandwidth required by commercial systems.
- Another stakeholder expressed concern in regards to network capacity stating that VA's network is not reliable or standardized, which can result in concurrency problems. It is very important that the VA system be designed to operate natively in an asynchronous environment.

9.4 Stakeholders Interviewed

Figure B-4.VHA Stakeholders

Name	Title
Amy Colon	Program Manager, Pharmacy Benefits Management Services
Anthony P. Morreale, PharmD	Assistant Chief Consultant for Clinical Pharmacy Services & Healthcare
Blake J. Lesselroth MD, MBI	Hospitalist and Informaticist
Brook Watts, MD	Senior Advisor for Health informatics
Carrie Patton	Clinical Implementation Coordinator
Cathy Davis, RN	Chief Nurse, Primary Care
Charles Demosthenes, MD	Physician Lead, Analytics and Connected Care
Christopher Lacey, PharmD	Associate Chief, Clinical Pharmacy
Daniel Papell, PharmD	Pharmacist Clinical Application Coordinator
Bill Weppner, MD, MPH	Primary Care Chief
Karen Hudgins	Director, Community Care Transformation
Kathleen Lysell, PsyD	National Mental Health Director For Informatics
Michael Icardi, MD	National Director of Pathology and Laboratory Medicine Services
Monica Lypson MD, MHPE	Director, Medical and Dental Education
Steve Fihn, MD, MPH	Director, Clinical System Development and Evaluation
Steve Lieberman, MD	Assistant Deputy Under Secretary for Health for Access to Care
Tim Heimann, PharmD	Chief, Pharmacy Service
Eric Burgess	Associate Chief Financial Officer for Managerial Cost Accounting, VHA Office of Finance
Jianji Yang, PhD	Lead Data Architect and Informaticist
Joan Clifford, DNP	Deputy Assistant for Deputy Under Secretary for Health for Access to Care
Judy McConnachie, MPH	Administrative Director, Clinical Business Intelligence
Laura J. Kroupa, MD	Chief Medical Informatics Officer
Linda McConnell, MSN	Chief Nursing Officer
Lynn Sanders, PharmD	Associate Chief Consultant, Clinical Informatics and Pharmacy Re-Engineering, Pharmacy Benefits Management
Michael A. Valentino, MHSA, RPh	Chief Consultant Pharmacy, Pharmacy Benefits Management Services
Michael L. Davis	Executive Director, Access & Clinic Administration Program, VHA
Neil C. Evans, MD	Chief Officer, Connected Care
Rachel B. Ramoni, DMD, ScD	Chief Research & Development Officer
Rob Silverman, PharmD	Assistant Chief Consultant, PBM Clinical Informatics
Richard Barrow, BSN, MSHI	Nursing Informaticist
Rob Silverman, PharmD	Assistant Chief Consultant, PBM Clinical Informatics
Sheila Ochylski, DNP	Chief Nursing Informatics Officer
Shilpa Patel-Teague, MHA	Director for Clinical Programs, VHA
Thomas Emmendorfer, Pharm.D	Deputy Chief Consultant, Pharmacy Benefits Management Services

Uche S. Uchendu, MD	Chief Officer, Office of Health Equity
Virginia S. Torrise, Pharm.D	Deputy Chief Consultant, Professional Practice and Clinical Informatics, Pharmacy Benefits Management
William Gunnar, MD, JD, FACHE	National Director of Surgery
William P. Patterson, MD, MSS	Network Director

Figure B-5. OI&T Stakeholders

Name	Title
Annette Gibbs-Skervin	Executive Director, Strategic Sourcing Transformation Management
Bill James	Deputy Assistant Secretary, Enterprise Program Management Office
Cynthia Bias	ASD VistA Evolution eHMP Product Manager
Daniel Carroll	IT Program Manager
Eugene Guglielmo	Senior Advisor, Health Data Management
Jack Galvin	Executive Director , End User Operations
Jason Hawsey	IT Specialist
Joel Russell	IT Specialist
John Short	Program Executive, VistA Evolution; Acting Deputy Director, DoD/VA Interagency Program Office
Keith Michael	VistA UX Product Manager
Kevin Meldrum	IT Specialist
Melanie Buechler	IT Specialist
Patrick Redington	IT Specialist
Roger Sigley	Program Manager
Roopangi Kadakia	Chief Cloud Strategist
Vanessa Davis	Health Product Support Director
Vitalia Devlin	Division Director, Health Product Support Clinical Product Support

10.0 Appendix C: Identification of Applicable Market Trends

Grant Thornton reviewed industry publications and research regarding the future direction of health IT and healthcare delivery. Publications and research included information from Gartner, Forrester and peer-reviewed medical journals. The following are trends identified as applicable to VA's EHR decision.

10.1 Precision Medicine

VA has long been a leader in research that incorporates new technologies in order to improve the care of Veterans. Precision medicine is defined as "treatments targeted to the needs of individual patients on the basis of genetic, biomarker, phenotypic, or psychosocial characteristics that distinguish a given patient from other patients with similar clinical presentations. Inherent in this definition is the goal of improving clinical outcomes for individual patients and minimizing unnecessary side effects for those less likely to have a response to a particular treatment."[23] In 2009, VA began pilot work to plan for the Million Veterans Project, with the goal of improving understanding of health, disease, and the complex interplay between genetics, environment, and behavior. As of August 2016, more than 500,000 veterans have been enrolled.[24–26] Precision medicine aims to increase quality/speed of clinically relevant analysis and interpretation of complex biological information both for VA patients and elsewhere.[27] Recent VA studies proposed and in progress use precision medicine to target advances in diagnosis and treatment of conditions as diverse as lung cancer, kidney disease, substance abuse disorders, PTSD, cardiovascular disease, and vision loss.[25,27]

In order to support precision medicine as it is used more widely in the clinical rather than solely research setting, there are several technical requirements for an EHR. In addition to development of data standards for genetic test results, there need to be common data formats using standardized medical terminologies.[28] EHRs should be able to populate genetic and pharmacogenomics data and integrate with clinical decision support tools. Assistance with medication dosing, facilitation of orders, improved alerts and reminders, display of relevant information, and workflow support are some of the efficiencies that can be realized.[28,29] EHRs' interfacing with research data warehouses will also allow cross-population queries and improvements in individual patients' care through analysis of larger patient data sets.[30]

10.2 Telehealth Services

As healthcare delivery transitions more and more to settings other than hospitals, the healthcare industry continues to innovate. Telehealth and Internet of Things and wearable technologies have the potential to transform care. Telehealth can be defined as "a broad variety of technologies and tactics to deliver virtual medical, health, and education services. Telehealth is not a specific service, but a collection of means to enhance care and education delivery."[31] Telehealth functionalities have been integrated in EHR systems and are already showing promising results in terms of patient satisfaction, cost reduction, and efficiency for providers.[32–34] Medicare has provided rural health guidelines highlighting services that can be provided via telehealth and are reimbursable.[35]

VA continues to develop ways of providing care to Veterans while improving quality, efficiency, and convenience. Approximately 25 percent of all Veterans live in predominantly rural areas, and they

are disproportionately older, which creates opportunities for new types of care.[36,37] Approximately 30 percent of Veterans have no access to the internet, and this group is also disproportionately older.[38]

VA Telehealth Services uses both synchronous (e.g. real-time videoconferencing between patients and a care team, remote medical device monitoring) and asynchronous (e.g. acquirement of and transmission of medical data for later review by providers, patient video education modules) communication to supplement face-to-face appointments and make receiving care more convenient for Veterans. Connected Care, which resulted from merging VA's Telehealth Services and Connected Health, is part of VA's efforts to streamline VA's digital health technologies to enrich Veteran care.[7,8] Connected Care is comprised of VA Telehealth Services, MyHealtheVet, VA Mobile Health, and the VHA Innovation Program. VA Telehealth Services uses both synchronous (e.g. real-time videoconferencing between patients and a care team, remote medical device monitoring) and asynchronous (e.g. acquirement of and transmission of medical data for later review by providers, patient video education modules) communication to supplement face-to-face appointments and make receiving care more convenient for Veterans.[7,8] Research shows that these initiatives have improve Veteran satisfaction by reducing travel and wait times.[8,9] In addition, providers endorse improved access, care coordination, and quality of care.[9] MyHealtheVet is VA's personal health record (PHR) which allows Veterans to record and view medical information, order medication refills, and send messages to their care team. VA Mobile Health develops apps to create new ways for Veterans and care teams to interact and coordinate care on mobile platforms. Finally, the VHA Innovation Program leverages both VA employees and private sector professionals to develop new ideas that improve VHA care and service to Veterans.[7,8]

In order to maximize the benefit of these care delivery mechanisms, an EHR must be able to manage multiple different types of communication. In addition to synchronous (e.g. real-time video transmission, remote patient data monitoring) and asynchronous (store-and-forward) transmission, integration of mobile adjuncts and wearable devices (Internet of Things) need to be considered. VA has shown interest in incorporating medical devices and Internet of Things into patient care responsibly, and is investigating ways to ensure the security of these devices.[39,40]

10.3 Advanced Computing

Advanced computing is leading to new evolutions in medical diagnosis, prognosis, and treatment. Artificial Intelligence (AI), defined broadly as "a branch of computer science dealing with the simulation of intelligent behavior in computers or the capability of a machine to imitate intelligent human behavior" is being utilized by the healthcare industry to power clinical decision support and diagnostic tools.[41,42] Technologies like machine learning (including deep learning/neural networks) and natural language processing, are being applied to parse clinical notes, text elements of lab values and other relevant data from the EHR and other clinical sources in order to enhance a physician's diagnostic and treatment capabilities and in some cases to actually act as a caregiver via mobile technologies.[42–44] AI tools (including large-scale implementations like Google's DeepMind and IBM's Watson) accomplish this by incorporating large amounts of clinical and subclinical data and then leveraging their high capacity processing capability in order to analyze this data and provide relevant information to the physician. Machine learning has the potential to assist physicians with differential diagnosis, treatment options suggestions and recommendations.[42,45,46]

Internally, VA Informatics and Computing Infrastructure (VINCI) is an initiative that provides computing resources to improve researchers' access to large amounts of Veteran data to facilitate analysis while protecting privacy and security. VINCI is also engaged in developing an ecosystem for

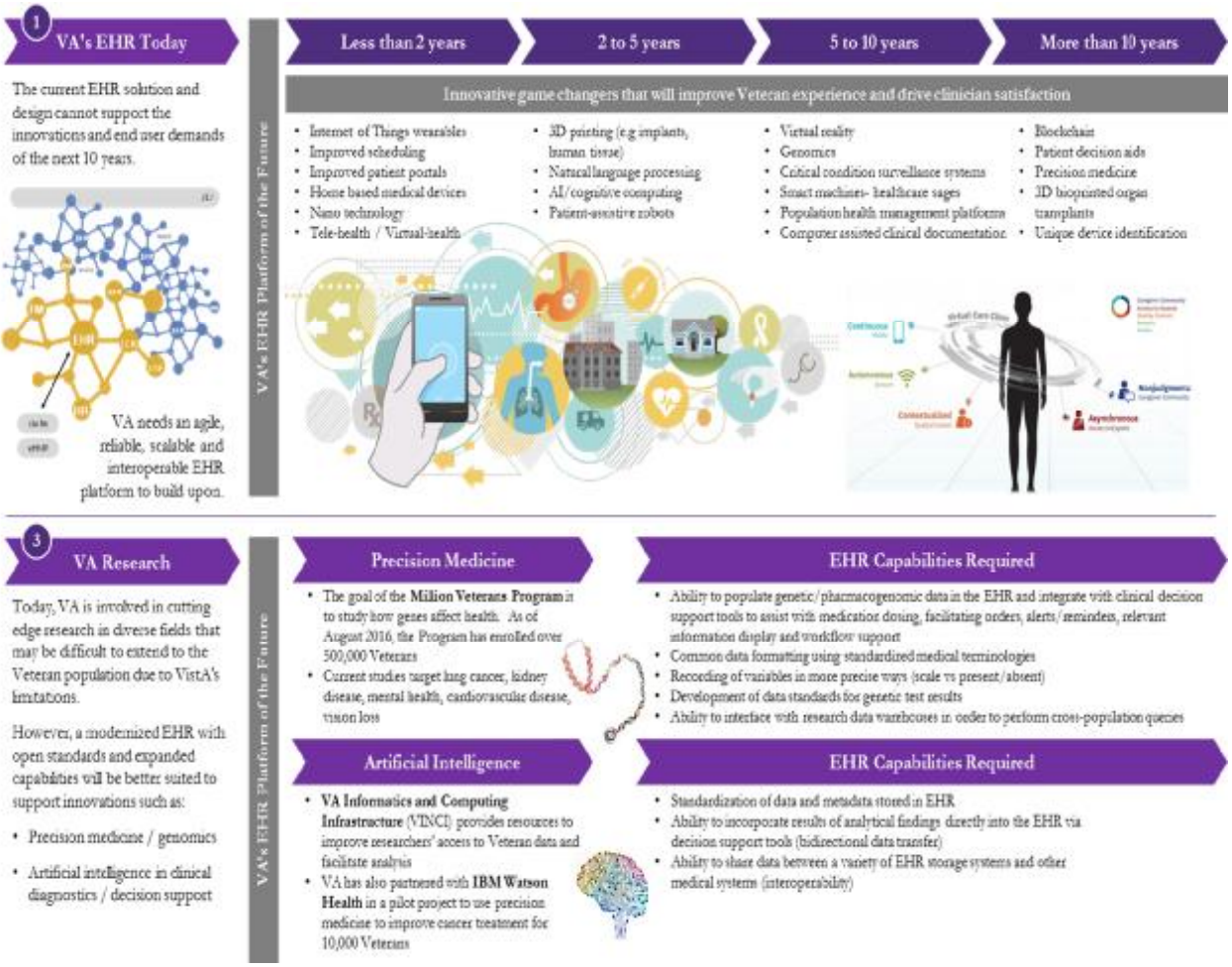
natural language processing that would ideally interface with VA's EHR[47–49] Research projects already in progress by VA researchers include: using reinforcement learning (one type of AI) with mobile health tools to manage chronic pain, employing natural language processing to assess treatment performance for patients with congestive heart failure.[43,44] Recently, VA engaged in a public-private partnership with IBM Watson in a pilot project to use precision medicine to improve cancer treatment for 10,000 Veterans.[50,51]

In order to employ these technologies clinically, there needs to be standardization of data and metadata that is stored in EHRs, the ability to incorporate results of analytical findings directly into an EHR via clinical decision support tools in a bidirectional manner, and the ability to communicate between a variety of EHR and other medical storage systems.[46]

10.4 Delivering Patient Care through Innovation

The graphic below (Figure C-1) looks at the current state of VA, including its EHR package and on-going research activities in conjunction with a view of potential future innovative game changers and the required modern EHR capabilities that will improve Veteran experience and drive clinician satisfaction.

Figure C-1. VA EHR Transformation[52]



11.0 Appendix D: Calculation of Cost Estimates

11.1 Option 1: COTS EHR

<table>
<tr><th>Option 1: COTS</th><th>Outcome</th></tr>
<tr><td>COTS Vendor total costs years 1-15</td><td>
1. COTS Cost Break down for Implementation Phase of the Software costs. Based on a survey of leading industry EHR provides
<table>
<tr><th></th><th>Included in COTs Quote</th><th>Cost Allocation</th></tr>
<tr><td>Cost Components</td><td></td><td></td></tr>
<tr><td>Software</td><td>Yes</td><td>28%</td></tr>
<tr><td>Vendor Team & Support</td><td>Yes</td><td>41%</td></tr>
<tr><td>Systems Integration</td><td>Yes</td><td>3%</td></tr>
<tr><td>IT Infrastructure HW & SW</td><td>No</td><td>6%</td></tr>
<tr><td>Application Support</td><td>No</td><td>11%</td></tr>
<tr><td>End user devices</td><td>No</td><td>2%</td></tr>
<tr><td>User training at Go-Live</td><td>No</td><td>8%</td></tr>
<tr><td>Other Project Cost</td><td>No</td><td>1%</td></tr>
<tr><td>Total</td><td>-</td><td>100%</td></tr>
</table>
2. Used an average of serval vendor ROM estimates for a COTS implementation average of $3.03B, this number was used as the basis for the estimate. This was divided by software (28%), Vendor Team & Support (41%) and Systems Integration (3%) for the total 10-year Implementation Cost of $4.21B. The $4.21B was then multiplied by the cost allocation for the given area to determine the component cost of these areas:

Total Vendor Cost = $\frac{\$3,032,333,333}{72\%}$ = $4,211,574,074
Software = 28% x $4,211,574,074 = $1,179,240,741
Vendor Team & Support = 41% x $4,211,574,074 = $1,726,745,370
IT Infrastructure HW & SW = 6% x $4,211,574,074 = $252,694,444
Systems Integration = 3% x $4,211,574,074 = $126,347,222
Application Support = 11% x $4,211,574,074 = $463,273,148
End user devices = 2% x $4,211,574,074 = $84,231,481
User training at Go-live = 8% x $4,211,574,074 = $336,925,926
Other Project Cost = 1% x $4,211,574,074 = $42,115,741

3. The implementation timeline was assumed to be 13 instances of VistA per year for 10 years to cover all 130 instances of VistA at VA. The annual implementation cost per year were determined by the following calculation:

Software = 10% x $1,179,240,741= $117,924,074
Vendor Team & Support = 10% x $1,726,745,370= $172,674,537

</td></tr>
</table>

- IT Infrastructure HW & SW = 10% x $252,694,444= $25,269,444
- Systems Integration = 10% x $126,347,222= $12,634,722
- Application Support = 10% x $463,273,148= $46,327,315
- End user devices = 10% x $84,231,481= $8,423,148
- User training at Go-live = 10% x $336,925,926 = $33,692,593
- Other Project Cost = 10% x $42,115,741= $4,211,574

4. Annual Maintenance and Support costs were derived from the vendor quotes by calculating the total amount of facilities per year being supported throughout the vendor's implementation phase and dividing non-service vendor costs by it.

Year	1	2	3	4	5	6	7	8	9	10
Fac/yr	0	1	7	10	25	25	25	25	25	25
Total Fac/yr	1	8	18	43	68	93	118	143	168	

Total Facility Live Years	660	
10 Year Costs	$1,097,000,000	Net Total 10 Year Cost
Per Year Per Facility Cost	$1,662,121 = $1,097,000,000/660	
Annual Cost for 168 Hospitals	$279,236,363 = 1,662,121 * 168 Hospitals	
Total Post Implementation M&S	$1,396,181,818 = 279,236,363 * year 11-15.	

However, as the number obtained is averaged with other vendor supplied numbers, post-implementation the annual cost are an average of $266,412,121 per year.

5. Data mapping costs were from previous efforts, VA was able to complete comprehensive data migration tasks at 66 sites in 6 years and 10 months. The resources for this effort were 20 FTE, plus 200hrs of overtime per instance; this corresponds to 7.47 sites per year. In order to meet VA's current mapping goals of 130 instances within 8-years, VA will need to map 16.25 sites per year; this is an increase of 218% over the previous effort. As the limiting factor effecting integration is available FTEs, VA will need to scale-up staffing to 43.52 FTEs, while maintaining 200hrs of available overtime per instance.
    1. Supporting Calculation:[14]
        - 5.1.1 Historical Data
            - 5.1.1.1 66 sites mapped / 6.833 years of effort = 7.47 site per year
            - 5.1.1.2 130 Total VistA Instances / 8 year project = 16.25 sites per year
            - 5.1.1.3 Subsequently a 218% faster project is need, the limiting constraint is assumed to be labor.
            - 5.1.1.4 20 FTE for original project tempo * 218% = 43.52 FTE needed
            - 5.1.1.5 ((FTE * Salary Level * Instances) + (Hourly Salary * OT Hours * Instances)) = $505,382,301

FTE Required	***Salary Level (GS13 , DC Locality)***	***Total VistA Instances to Migrate***	***Hourly Salary + OT***	***OT hours***
43.52	$89,033	130	$64.20	200
Migration Phase(Single Instance)	**Per Site Cost**	**Notation**		
Data Mapping	$3,887,556	Calculated as ((FTE * Salary Level * Instances) + (Hourly Salary * OT Hours * Instances))/130 #This is how we did the data		

			mapping cost for the VDP
	Total Cost to Migrate a Single Instance	$3,887,556	Sum of all component costs
	Total Cost to Migrate All VistA Instances	$505,382,301	Per instance cost multiplied by number of instances

Total 15-year Project Costs

6. To calculate the total 15-year project cost the following calculations were used.
   - Total 10-year Vendor Cost= sum of the Vendor total cost (software component costs plus annual maintenance and support costs) for years 1 through 10.
   - Change management cost was assumed to be 25% given the scale and complexity of VA
     Change management cost= $\frac{\text{Total 10-year Vendor Cost}}{0.75}$ x 0.25 = $1,052,893,519
   - Data migration cost were determined to be $505,382,301
   - Post-Implementation Software Cost = sum of the support totals for years 11-15 = $1,332,060,606
   - Prime Integrator = Software cost x (11/6) = $2,161,941,358
   - VA PMO= ((10-year Vendor cost + Change Management Cost + Data Migration Cost + Post-Implementation Software Cost + Prime Integrator)/0.8)x (0.2) = $2,315,962,964
   - Cloud Hosting:
     - This model assumes VA's storage, RAM and needed processing cores are equivalent to the values stated in the VDP Whitepaper, page 28.
     - AWS GovCloud estimates were utilized for values. As hosting is a commodity within industry, these costs were deemed representative of the industry

Storage Average (TB)	RAM (GB)	Cores
729.3	17,160	4290

Storage Cost (per TB/mo)	$656,370 (729.3TB x $0.9 $0.9 Storage cost per TB)
Storage Cost Per year	$7,876,440 (Storage cost per month x 12)

Each x1 server node has 72 cores.
4290 cores/72 = 59.58. Hosts are dedicated so 60 blades are needed

Node cost is $73,919 per year/per node [17,18]

Processing Cost per Year: (Assume x1 Nodes Dedicated Host, Up-Front Pay)	$4,435,140 (Cost Per-node x Needed Nodes)

Total 1-year Cost	$12,311,580 (Cost Per-TB + Processing Cost)
Total 10-year Cost	$123,115,800
Total 15-year Cost	$184,673,700

   - Contingency was 20% of the total of 10-year Vendor cost + Change Management Cost + Data Migration Cost + Post- Implementation Software Cost + Prime Integrator + VA PMO + cloud hosting = $2,352,897,704
   - **Total 15-year Cost $14,117,386,226**

11.2 Option 2: COTS with eHMP

<table>
<tr><th>Costing Step</th><th>Outcome</th></tr>
<tr><td>COTS Costing</td><td>For the COTS portion of Option 2: COTS + eHMP, the same costing approach was used as in Option 1: COTS</td></tr>
<tr><td>eHMP</td><td>The eHMP component was costed using data provided by VA leadership
The Year 1 Startup cost are as followed:
<table>
<tr><th>Start Up Cost</th><th>Year 1</th></tr>
<tr><td>Hosting at a Commercial Cloud- Services (OM)</td><td>$ 18,000,000</td></tr>
<tr><td>Operational Support- Services (OM)</td><td>$ 7,000,000</td></tr>
<tr><td>Software license Renewal (OM)</td><td>$ 4,000,000</td></tr>
<tr><td>New SW Licenses (DME)</td><td>$ 22,000,000</td></tr>
<tr><td>Cloud Migration- Services (DME)</td><td>$ 8,000,000</td></tr>
<tr><td>WAN Connection- Equipment (DME)</td><td>$ 11,000,000</td></tr>
<tr><td>Wan-Telecommunication Services (OM)</td><td>$ 1,600,000</td></tr>
<tr><td>VHA-Org. Change Management (OCM)</td><td>$ 25,000,000</td></tr>
<tr><td>Total</td><td>$ 96,600,000</td></tr>
</table>
The Recurring eHMP Costs for Year 2 to Year 15
<table>
<tr><th>Recurring Cost</th><th>Year 1</th></tr>
<tr><td>Hosting at a Commercial Cloud- Services (OM)</td><td>$ 18,000,000</td></tr>
<tr><td>Operational Support- Services (OM)</td><td>$ 7,000,000</td></tr>
<tr><td>Software license Renewal (OM)</td><td>$ 4,000,000</td></tr>
<tr><td>Wan-Telecommunication Services (OM)</td><td>$ 1,600,000</td></tr>
<tr><td>Total</td><td>$ 30,600,000</td></tr>
</table>
The total 15 year costs were determined to be $525,000,000</td></tr>
<tr><td>Adding COTs and eHMP</td><td>The eHMP costs were added to the COTS cost for the 15-year total.
<table>
<tr><th>Years</th><th>eHMP</th><th>COTs</th></tr>
<tr><td>1</td><td>$96,600,000</td><td>$421,157,407</td></tr>
<tr><td>2</td><td>$30,600,000</td><td>$421,157,407</td></tr>
<tr><td>3</td><td>$30,600,000</td><td>$421,157,407</td></tr>
</table></td></tr>
</table>

	4	$30,600,000	$421,157,407
	5	$30,600,000	$421,157,407
	6	$30,600,000	$421,157,407
	7	$30,600,000	$421,157,407
	8	$30,600,000	$421,157,407
	9	$30,600,000	$421,157,407
	10	$30,600,000	$421,157,407
	11	$30,600,000	$266,945,425
	12	$30,600,000	$266,945,425
	13	$30,600,000	$266,945,425
	14	$30,600,000	$266,945,425
	15	$30,600,000	$266,945,425
	Total 15-year Costs		**$6,068,634,680**
	*assuming average COTs Vendor Costs		

Total Project Costs Calculation

The total project costs were calculated as in the same method as in Option 1: COTS.

Total 15-year Project Cost	**Total Cost**	**% of Total Cost**
Total 10-year Vendor Cost	$ 4,583,574,074	29%
Change Management Cost	$ 1,527,858,025	10%
Data Migration Cost	$ 505,382,301	3%
Post-Implementation Software Cost	$ 1,485,060,606	10%
Prime Integrator	$ 2,161,941,358	14%
VA PMO	$ 2,565,954,091	16%
Cloud Hosting	$ 184,673,700	1%
Subtotal	**$ 13,014,444,155**	83%
Contingency (20%)	$ 2,602,888,831	17%
Total 15-year Cost	**$15,617,332,985**	

11.3 Option 3: Commercialization of VistA

Costing Step	Outcome
VistA Calculations	As in the other analysis, a vendor ROM estimate for EHR implementation of $554M was used as the basis; this number was divided by the percentage cost centers for: software (28%), Vendor Team & Support (41%), Systems Integration (3%) and Go-Live training (8%) for a total Vendor Cost of $694,186,047. An identical distribution of EHR cost centers where utilized as in the commercial SaaS (Option 4: COTS SaaS) model.

Total Vendor Cost=

- Total Vendor Cost = $\frac{\$554,000,000}{80\%}$ = $694,186,047

The $694,186,047 was then multiplied by the cost allocation for the given area to determine the component cost of these areas:

Costs Components	Cost Allocation	Component	
Software	28%	$	194,372,093
Vendor Team & Support	41%	$	284,616,279
IT Infrastructure HW & SW	6%	$	41,651,163
Systems Integration	3%	$	20,825,581
Application Support	11%	$	76,360,465
End user devices	2%	$	13,883,721
User training at Go-Live	8%	$	55,534,884
Other Project Cost	1%	$	6,941,860
Total		**$**	**694,186,047**

The annual maintenance and support costs was calculated for each year by the formula:

- Annual Maintenance & Support Cost= $\frac{1}{\text{\# of Instances Implemented}}$ x $1,800,000 (average cost M&S per VistA instance)

The annual maintenance cost for the implementation phase (years 1-10) were included in the cost estimate.

VistA Modernization

VistA 4 Evolution Cost Centers were pulled from the VistA 4 Life Cycle Cost Estimate document.

The relevant cost centers were determined to be:

Government Program Management	$	54,630,000
Program Management-Contractor		
System Engineering	$	84,200,000
API Exposure	$	36,960,000
API Exposure 2.0	$	8,780,000
API Exposure 2.0-Phase II	$	6,390,000
Clinical Capabilities- EHR Certification 2014	$	859,890,000
Clinical Decision Support	$	23,450,000
Clinician Services (Misc. clinical modules)	$	30,520,000
Clinician Services Lab/Pharmacy	$	97,910,000
Clinician Services Phase II	$	71,600,000
Clinician User Interfaces	$	85,530,000
eHMP Enterprise Wide Deployment		

	Enhancements to Scheduling Module	$	4,090,000
	FileMan Modernization	$	1,370,000
	Immunization Module	$	15,920,000
	Interoperability/Data Standard (FileMan)	$	29,010,000
	Interoperability/Data Standard (Pharmacy)	$	64,620,000
	Laboratory Module Enhancements	$	28,170,000
	Laboratory Module Modernization	$	30,500,000
	Pharmacy Module	$	25,100,000
	Radiology	$	29,580,000
	Scheduling Module	$	8,520,000
	Specialty Clinical Modules (Women's Health)	$	21,050,000
	Veteran Authorization and Preferences	$	7,090,000
	VistA Immunization Enhancement	$	1,800,000
	VistA Service Assembler- Phase II		
	VistA Services Assembler		
	Total	**$**	**1,626,680,000**

It was assumed a risk sharing of 50:50 would occur between VA and the commercial vendor, which lowered this amount to $813,340,000.

This was then distributed over a 10-year implementation period on an equal basis of 10% per year, or $81,334,000 annually throughout implementation.

15-Year Project Costs

To calculate the total 15-year project cost the following calculations were used.

- Total 10-year Vendor Cost= sum of the Vendor total cost (software component costs plus annual maintenance and support costs) for years 1 through 10 = $1,507,526,047
- Change management cost was assumed to be 25% given the scale and complexity of VA Change management cost= $\frac{\text{Total 10-year Vendor Cost}}{0.75} \times 0.25 =$ $1,109,047,840
- Data migration cost were determined to be $505,382,301 with the same methodology as in the rest of the Options as VistA does not have a common model and enforced data standards.
- Post-Implementation Software Cost = sum of support costs total for years 11-15 = $1,170,000,000
- Prime Integrator = Software cost x (11/6) = $1,707,933,673
- VA PMO costs = ((10-year Vendor cost + Change Management Cost + Data Migration Cost + Post- Implementation Software Cost + Prime Integrator)/0.8)x (0.2) = $2,328,407,136
- Contingency was calculated at 20% of the total of 10-year Vendor cost + Change Management Cost + Data Migration Cost + Post- Implementation Software Cost + Prime Integrator + VA PMO = $1,665,659,399
- Total 15-year costs are calculated at = $9,993,956,395

11.4 Option 4: SaaS

<table>
<tr><th>Costing Step</th><th>Outcome</th></tr>
<tr><td>Vendor ROM Cost</td><td>
Used an average of serval vendor ROM estimates for a COTS implementation average of $3.03B, this number was used as the basis for the estimate. This number was then multiplied by a scalar factor of .79 in order to adjust the cost COTS average to a SaaS implementation number.

Scalars are derived as follows:

<table>
<tr><th></th><th>Implementation Costs</th><th>Yearly Cost (After Year 1)</th><th>5-yr TCO</th></tr>
<tr><td>Non-SaaS:</td><td>33000</td><td>4000</td><td>48000</td></tr>
<tr><td>SaaS:</td><td>26000</td><td>8000</td><td>58000</td></tr>
<tr><td>Factor:</td><td>0.787878788</td><td>2</td><td>1.208333333</td></tr>
<tr><td>Narrative:</td><td>Implementation costs (including 1st year licensing cost) for a SaaS option is 79% of what is would be for a COTS option</td><td>Annual recurring costs for a SaaS option are 200% of what it would be for a COTS option</td><td>This is built out to a 5-year model. At this resolution, SaaS is more expensive than COTS by about %21</td></tr>
</table>

Total SaaS Implementation Costs = Vendor Average * .79 = $2,395,543,333.33

This was divided by software (28%), Vendor Team & Support (41%) and Systems Integration (3%) for the total 10-year Implementation Cost of $3.3B. The $3.3B was then multiplied by the cost allocation for the given area to determine the component cost of these areas:

Total SaaS Vendor Cost=

• Total Vendor Cost = $\frac{\$2,395,543,333}{72\%}$ = $3,327,143,519

The software cost components were determined by the following calculations. These were then scaled over the course of the 10-year implementation and 5-year post-go-live phase.
• Software = 28% x $3,327,143,519 = $931,600,185
• Vendor Team & Support = 41% x $3,327,143,519 = $1,364,128,843
• IT Infrastructure HW & SW = 6% x $3,327,143,519 = $199,628,611
• Systems Integration = 3% x $3,327,143,519 = $99,814,306
• Application Support = 11% x $3,327,143,519 = $365,985,787
• End user devices = 2% x $3,327,143,519 = $66,542,870
• User training at Go-live = 8% x $3,327,143,519 = $266,171,481
• Other Project Cost = 1% x $3,327,143,519 = $33,271,435

<table>
<tr><th>Year</th><th>Number of Hospitals</th></tr>
<tr><td>1</td><td>0</td></tr>
<tr><td>2</td><td>1</td></tr>
<tr><td>3</td><td>7</td></tr>
</table>
</td></tr>
</table>

4	10
5	25
6	25
7	25
8	25
9	25
10	25
11	-
12	-
13	-
14	-
15	-

The annual maintenance and support costs was calculated for each year by the formula:

- Annual Maintenance & Support Cost= $\frac{1}{\text{\# of Hospitals Implemented}}$ x $532,824,242 (average cost)

- The vendor provided a range of annual maintenance post-go-live of $220,000,000-$300,000,000. These costs were averaged $266,412,121, as per the method utilized for implementation, this number was then multiplied by a scalar factor of 2 to yield: $532,824,242

15-year project Cost

To calculate the total 15-year project cost the following calculations were used.

- Total 10-year Vendor Cost= sum of the Vendor total cost (software component costs plus annual maintenance and support costs) for years 1 through 10 = $3,327,143,519
- Change management cost was assumed to be 25% given the scale and complexity of VA
  Change management cost= $\frac{\text{Total 10-year Vendor Cost}}{0.75}$ x 0.25 = $1,109,047,840
- Data migration cost were determined to be $505,382,301 with the same methodology as in Option 1: COTS.
- Post-Implementation Software Cost = sum of the support totals for years 11-15 = $2,664,121,212
- Prime Integrator = Software cost x (11/6) = $1,707,933,673
- VA PMO= ((10-year Vendor cost + Change Management Cost + Data Migration Cost + Post-Implementation Software Cost + Prime Integrator)/0.8)x (0.2) = $2,328,407,136
- Contingency was 20% of the total of 10-year Vendor cost + Change Management Cost + Data Migration Cost + Post- Implementation Software Cost + Prime Integrator + VA PMO = $2,328,407,136
- Total 15-Year Cost = $13,970,442,816

12.0 Appendix E: VistA Packages

The table below provides a complete list of VistA packages. Modules specific to EHR are bolded and italicized.

Package Type	Package Name	Package Name
Clinical	Admission Discharge Transfer (ADT)	Methicillin Resistant Staph Aurerus (MRSA)
Clinical	Ambulatory Care Reporting	Mobile Electronic Documentation (MED)
Clinical	Anticoagulation Management Tool (AMT)	Mobile Scheduling Applications Suite (MBAA)
Clinical	Automated Service Connected Designation (ASCD)	Multiple Sclerosis Surveillance Registry (MSSR)
Clinical	Bar Code Expansion (BCE)	Nationwide Health Information Network Adapter (NHIN)
Clinical	Beneficiary Travel	***Nursing***
Clinical	Blind Rehabilitation	Nutrition and Food Service (NFS)
Clinical	***Care Management***	ONCOLOGY
Clinical	Clinical Case Registries	Patient Appointment Info. Transmission (PAIT)
Clinical	***Clinical Procedures***	***Patient Assessment Documentation Package (PADP)***
Clinical	Clinical/Health Data Repository (CHDR)	***Patient Care Encounter (PCE)***
Clinical	***Computerized Patient Record System (CPRS)***	Patient Centered Management Module (PCMM Web)
Clinical	***CPRS: Adverse Reaction Tracking (ART)***	***Patient Record Flags***
Clinical	***CPRS: Authorization Subscription Utility (ASU)***	Pharm: Automatic Replenish / Ward Stock (AR/WS)
Clinical	***CPRS: Clinical Reminders***	Pharm: Bar Code Medication Administration (BCMA)
Clinical	***CPRS: Consult/Request Tracking***	Pharm: Benefits Management (PBM)
Clinical	***CPRS: Health Summary***	Pharm: Consolidated Mail Outpatient Pharmacy
Clinical	***CPRS: Problem List***	Pharm: Controlled Substances
Clinical	***CPRS: Text Integration Utility (TIU)***	Pharm: Data Management (PDM)
Clinical	Dentistry	Pharm: Drug Accountability
Clinical	Electronic Wait List	Pharm: Inpatient Medications
Clinical	Emergency Department Integration Software (EDIS)	Pharm: National Drug File (NDF)
Clinical	Functional Independence Measurement (FIM)	Pharm: Outpatient Pharmacy
Clinical	Group Notes	Pharm: Prescription Practices (PPP)
Clinical	HDR - Historical (HDR-Hx)	Primary Care Management Module (PCMM)
Clinical	Health Management Platform	Prosthetics
Clinical	Home Based Primary Care (HBPC)	***Quality Audiology and Speech Analysis and Reporting (QUASAR)***
Clinical	Home Telehealth	Radiology / Nuclear Medicine
Clinical	Immunology Case Registry (ICR)	RAI/MDS
Clinical	***Incomplete Records Tracking (IRT)***	Registries Airborne Hazard Open Burn Pit (AHOBPR)
Clinical	***Intake and Output***	Registries Military Eye Vision Injury (MEVIR)
Clinical	Laboratory	Remote Order Entry System (ROES)
Clinical	Laboratory: Anatomic Pathology	Scheduling

Clinical	Laboratory: Blood Bank	Shift Handoff Tool
Clinical	Laboratory: Blood Bank Workarounds	Social Work
Clinical	Laboratory: Electronic Data Interchange (LEDI)	Spinal Cord Dysfunction
Clinical	Laboratory: Emerging Pathogens Initiative (EPI)	Standards & Terminology Services (STS)
Clinical	Laboratory: Howdy Computerized Phlebotomy Login Process	Surgery
Clinical	Laboratory: National Laboratory Tests (NLT) Documents and LOINC Request Form	Traumatic Brain Injury (TBI)
Clinical	Laboratory: Point of Care (POC)	***Virtual Patient Record***
Clinical	Laboratory: Universal Interface	VistA Imaging System
Clinical	Laboratory: VistA Blood Establishment Computer Software (VBECS)	VistAWeb
Clinical	Lexicon Utility	Visual Impairment Service Team (VIST)
Clinical	***Medicine***	***Vitals / Measurements***
Clinical	Mental Health	Women's Health
Financial-Administrative	***Accounts Receivable (AR)***	Hospital Inquiry (HINQ)
Financial-Administrative	Auto Safety Incident Surv Track System (ASISTS)	ICD-9-CM
Financial-Administrative	Automated Information Collection System (AICS)	IFCAP
Financial-Administrative	Automated Medical Information Exchange (AMIE)	***Incident Reporting***
Financial-Administrative	***Bed Management Solution (BMS)***	***Income Verification Match (IVM)***
Financial-Administrative	***Clinical Monitoring System***	***Integrated Billing (IB)***
Financial-Administrative	***Compensation and Pension Record Interchange (CAPRI)***	***Integrated Patient Funds***
Financial-Administrative	Current Procedural Terminology (CPT)	Library
Financial-Administrative	Decision Support System (DSS) Extracts	Occurrence Screen
Financial-Administrative	***Diagnostic Related Group (DRG) Grouper***	Patient Representative
Financial-Administrative	Electronic Claims Management Engine (ECME)	Personnel and Accounting Integrated Data (PAID)
Financial-Administrative	Engineering (AEMS / MERS)	Police and Security
Financial-Administrative	***Enrollment Application System***	Quality Management Integration Module
Financial-Administrative	Equipment / Turn-In Request	Record Tracking
Financial-Administrative	Event Capture System (ECS)	Release of Information (ROI) Manager
Financial-Administrative	***Fee Basis***	Veterans Identification Card (VIC/PICS)
Financial-Administrative	Fugitive Felon Program (FFP)	Voluntary Service System (VSS)
Financial-Administrative	Generic Code Sheet (GCS)	WebHR
Financial-Administrative	Health Eligibility Center (HEC)	Wounded Injured and Ill Warrior

HealtheVet	Breast Care Registry	Pharm: Medication Order Check Healthcare Application (MOCHA)
HealtheVet	Clinical Information Support System (CISS)	Pharm: Pharmacy Data Update (DATUP)
HealtheVet	Electronic Signature (ESig)	Pharm: Pharmacy Enterprise Customization System (PECS)
HealtheVet	HealtheVet Web Services Client (HWSC)	Pharm: Pharmacy Product System - National (PPS-N)
HealtheVet	MyHealtheVet	Registries
HealtheVet	National Utilization Management Integration (NUMI)	***Spinal Cord Injury and Disorders Outcomes (SCIDO)***
HealtheVet	***Occupational Health Record-keeping System (OHRS)***	VA Enrollment System (VES)
HealtheVet	Patient Advocate Tracking System (PATS)	Veterans Personal Finance System (VPFS)
HealtheVet	Person Services	VHA Point Service (Kiosks)
Infrastructure	***Capacity Management Tools***	M-to-M Broker
Infrastructure	Duplicate Record Merge: Patient Merge	Name Standardization
Infrastructure	Electronic Error and Enhancement Reporting (E3R)	National Online Information Sharing (NOIS)
Infrastructure	Enterprise Exception Log Service (EELS)	National Patch Module (NPM)
Infrastructure	FatKAAT	Network Health Exchange (NHE)
Infrastructure	FileMan	Patient Data Exchange (PDX)
Infrastructure	FileMan Delphi Components (FMDC)	Remote Procedure Call (RPC) Broker
Infrastructure	Health Data Informatics	Resource Usage Monitor (RUM)
Infrastructure	HL7 (VistA Messaging)	Single Sign on/User Context (SSO/UC)
Infrastructure	Institution File Redesign (IFR)	SlotMaster (Kernel ZSLOT)
Infrastructure	KAAJEE	SQL Interface (SQLI)
Infrastructure	Kernel	Standard Files and Tables
Infrastructure	Kernel Delphi Components (KDC)	Statistical Analysis of Global Growth (SAGG)
Infrastructure	Kernel Toolkit	Survey Generator
Infrastructure	Kernel Unwinder	System Toolkit (STK)
Infrastructure	List Manager	VistA Data Extraction Framework (VDEF)
Infrastructure	MailMan	VistA System Monitor (VSM)
Infrastructure	Master Patient Index (MPI)	VistALink
Infrastructure	Medical Domain Web Services (MDWS)	XML Parser (VistA)